

Moriond08-Cosmology - Mozilla Firefox 3 Beta 5

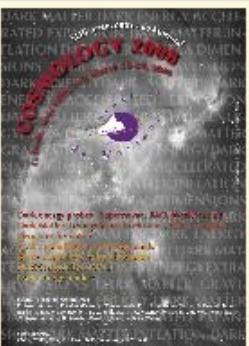
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43<sup>rd</sup> Rencontres de Moriond  
La Thuile (Val d'Aosta, Italy)  
March 15 - 22, 2008

## Cosmology



Information updated (28/02/09) Registration is closed Final schedule Participants Proceedings: Instructions

**Main topics:**

- A. Dark Energy**
- B. Dark Matter**
- C. Structure Formation: simulation input to cosmology**
- D. CMB**
- E. Theoretical Perspectives**

Scientific Program Committee

R. Ansari (Orsay) , P. Astier (Paris) , C. Canizares (MIT) , J. Dumarchez (Paris) , Y. Giraud-Héraud (Paris) , J.-P. Kneib (Marseille) , D. Langlois (Paris) , C. Magnéville (Saclay) , H. McCracken (Paris) , C. Rosset (Orsay) , B. Semelin (Paris) , J. Trần Thành Văn (Orsay) ,

Done

gkrellm pine - Shell - Konsole <2> Bernstein\_HEPlunch\_200801

# Outline

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- M. Vivier: Indirect Dark Matter Search with H.E.S.S.
- J. Guy: Introductory Review of Cosmology with SN Ia
- J. Frieman: SDSS Science
- K. Dawson: Dust-free Supernovae with HST
- M. Kowalski: New Cosmology Constraints from SN Ia
- J. Bernstein: Dark Energy Survey SNe
- A. Ealet: SNAP-L



# Indirect searches for Dark Matter with the H.E.S.S. high energy $\gamma$ -rays telescope array.

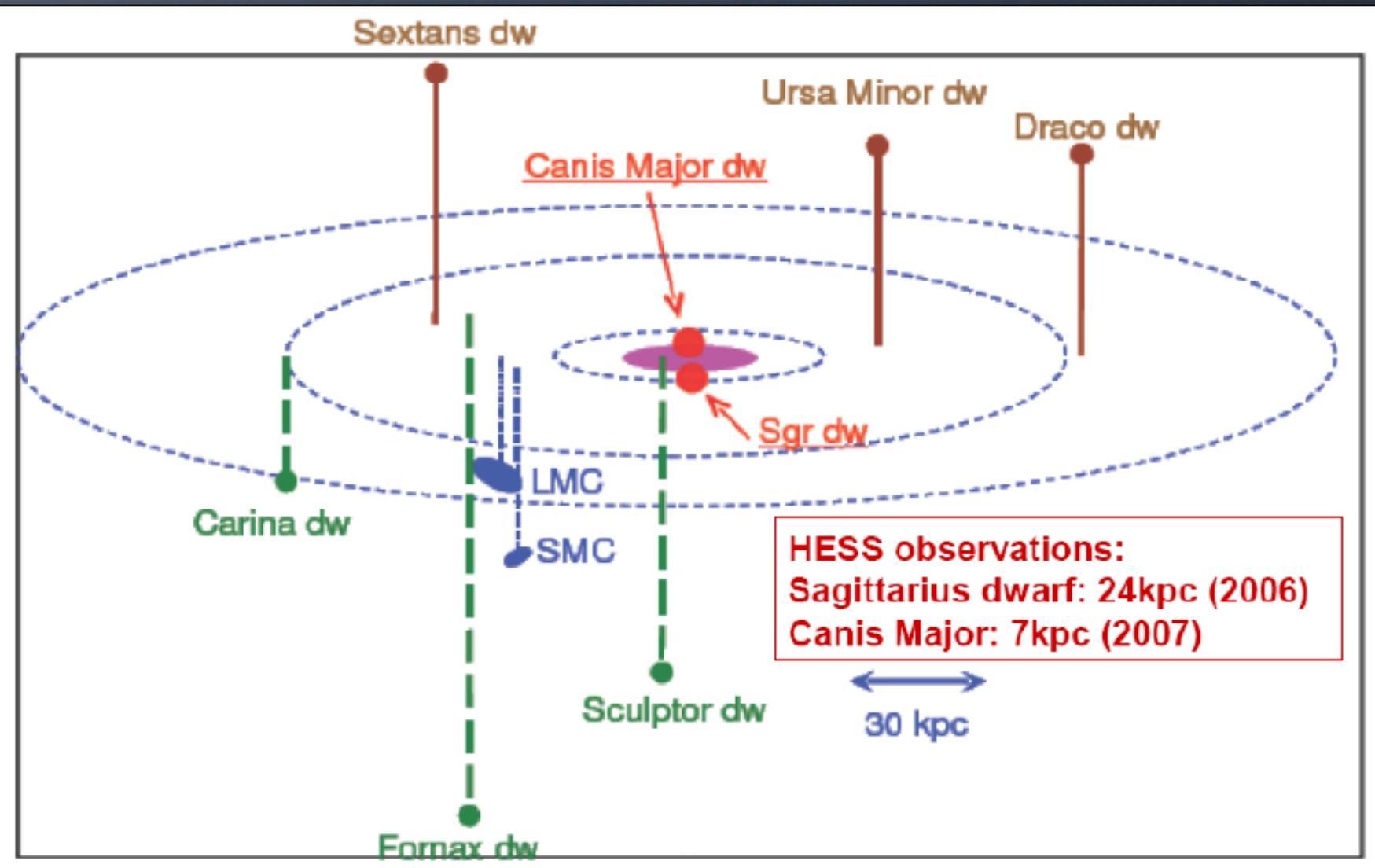
43<sup>rd</sup> Rencontres de Moriond  
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M. Vivier

IRFU/SPP

CEA-Saclay, France

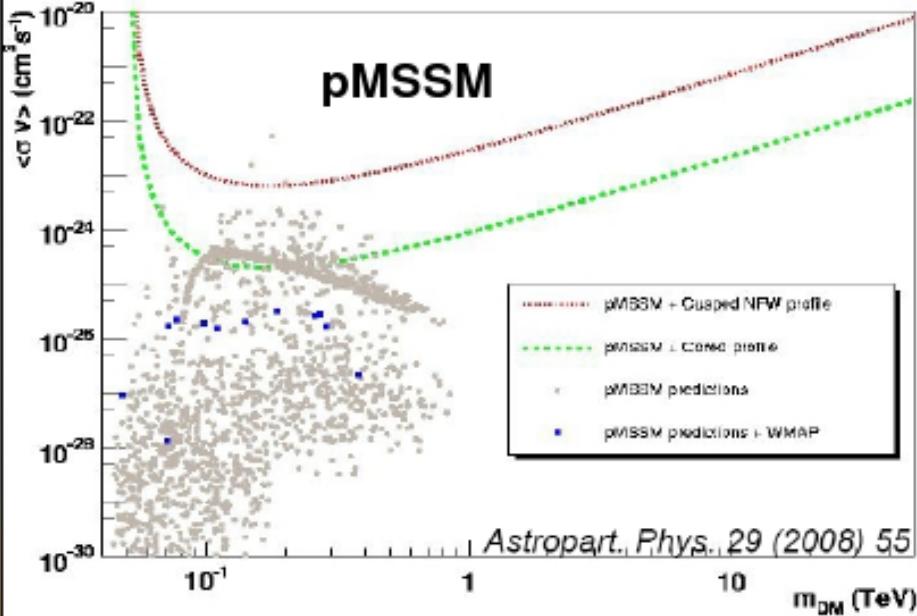
# Satellite galaxies of the Milky Way



# Constraints on WIMPs models

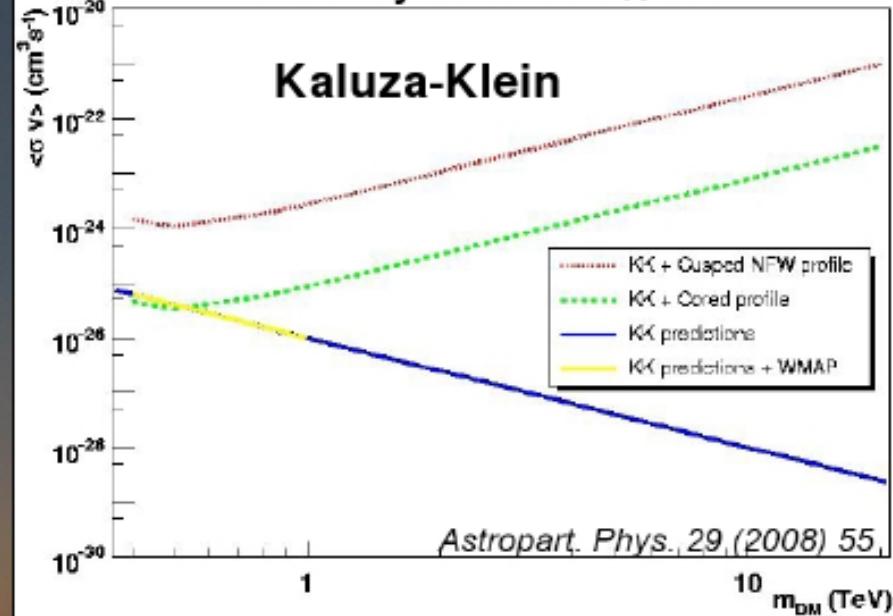
Sensitivity curve at 95% C.L.

pMSSM



Sensitivity curve at 95% C.L.

Kaluza-Klein



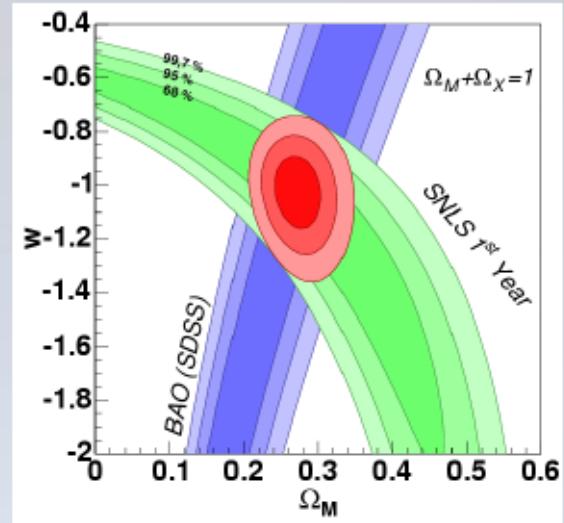
$$\langle\sigma v\rangle \sim 2 \cdot 10^{-25} \text{ cm}^3 \text{s}^{-1} \text{ (core)}$$
$$\langle\sigma v\rangle \sim 6 \cdot 10^{-24} \text{ cm}^3 \text{s}^{-1} \text{ (NFW)}$$

Some pMSSM models excluded in the case of the **cored profile**.

$$\langle\sigma v\rangle \sim 5 \cdot 10^{-26} \text{ cm}^3 \text{s}^{-1} \text{ (core)}$$
$$\langle\sigma v\rangle \sim 10^{-24} \text{ cm}^3 \text{s}^{-1} \text{ (NFW)}$$

The **core profile** excludes KK models compatible with the DM relic density as measured by WMAP

# Introduction review on cosmology with Type Ia supernovae

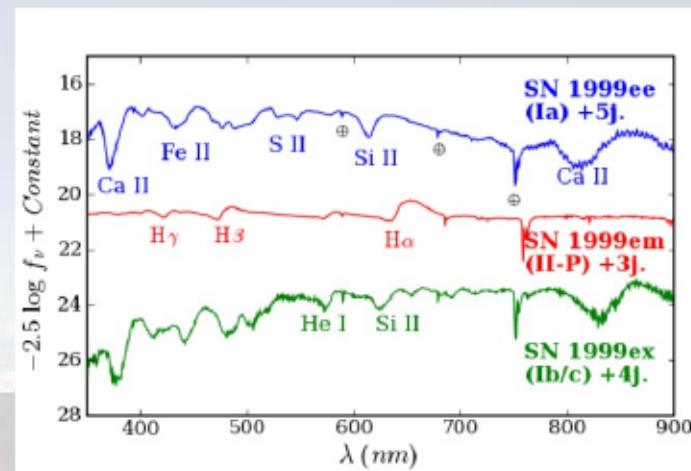
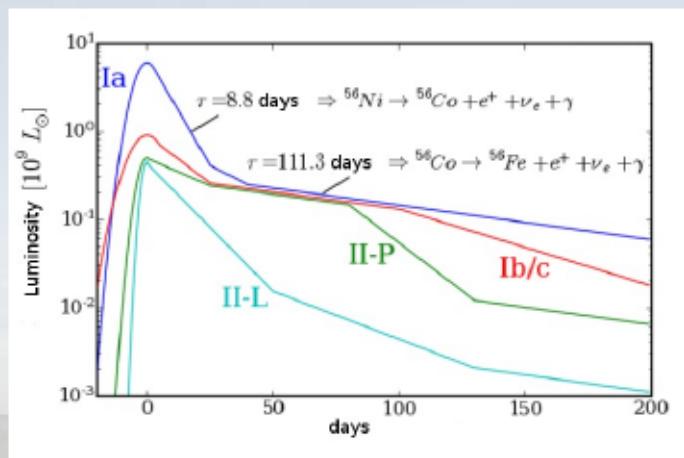


Julien GUY  
LPNHE IN2P3/CNRS Universités Paris VI et VII

# Type Ia Supernovae

Thermonuclear explosion of a star :

- very bright :  $10^{10}$  sun luminosity
- rare :  $\sim 1$  per galaxy per millennium
- light curve duration :  $\sim 1$  month
- peak brightness dispersion  $\sim 40\%$
- precision on distance modulus  $\sim 0.15$
- identified by spectroscopy,  
broad absorption features =>  
ejecta velocity and chemical composition
- progenitor is likely to be a white dwarf fed  
with material from a companion star



# Analysis steps of a SNe Ia survey

## - Detection :

- novel technique with SNLS : “rolling search”  
same fields are observed every 4 days  
=> full light-curve of SNe (no missing early-time data)  
=> better control of the selection bias
- the lower the redshift, the larger the required field of view  
=> nearby SNe are now technically more difficult to detect than high-z SNe (for an equivalent exposition)

## - Spectroscopic identification :

- photometric pre-selection or ranking required
- limitation of high-z surveys  
(SNLS: equivalent time allocation on CFHT (3.6m)  
for photometry as for 8m-class telescopes for spectroscopy)  
-> alternative : photometric identification (see talks by Bazin, Ripoche)

## - Photometry

## - Calibration

- calibration is fundamental for SNe cosmology
- it is one of the main limitations today (more details later)

## - Light-curve fitting / distance estimate

(fit of Hubble diagram)

6

## Light-curve fitting / distance estimate

The goal is to compare fluxes at different  $z$  :

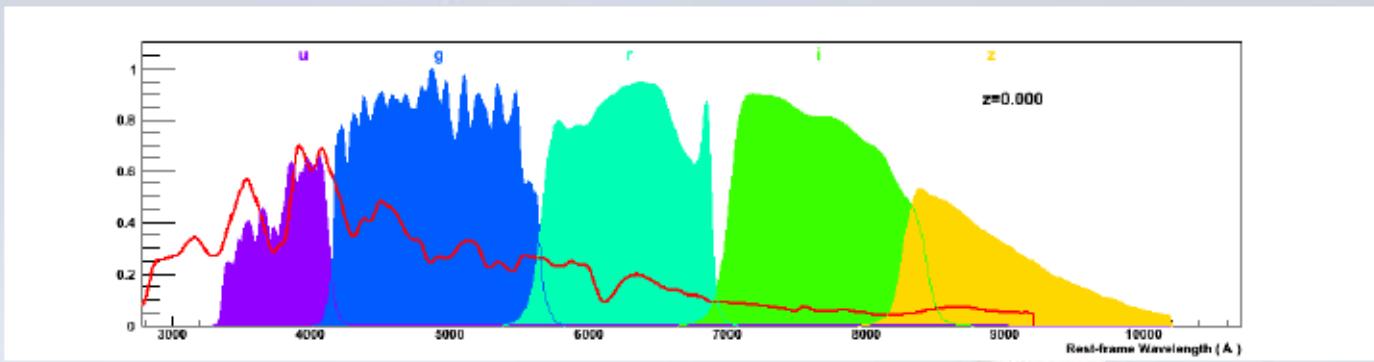
- at the same wavelength (range)
- at the same phase of the supernova light curve

$$\frac{f(z_1, T_{rest})}{f(z_2, T_{rest})} = \left( \frac{d_L(z_2)}{d_L(z_1)} \right)^2$$

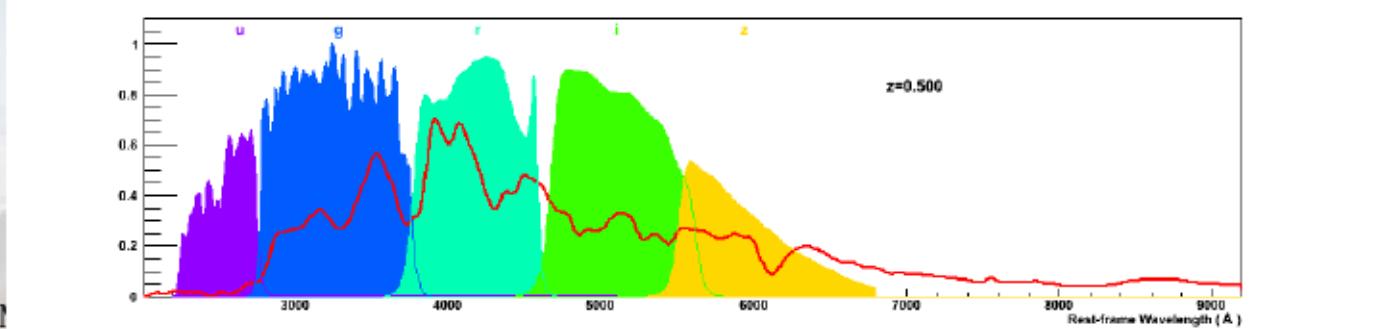
What is measured is a limited set of photometric observations at various phases and in few filters.

=> a full model of the spectral evolution of the SN is needed to 'interpolate' measurements across phase x wavelength.

$z=0$



$z=0.5$



## Light-curve fitting / distance estimate

Two very different approaches :

### MLCS (as used by GOODS and ESSENCE)

Directly extract a distance estimate from light-curves

=> need a training set of SNe for which we know a priori the distance

1) Apply k-corrections : transform photometric measurements to standard rest-frame bands

2) Fit corrected light curves to a set of templates

Consider the (B-V) color excess as a measurement of host galaxy extinction

### SALT and SIFTO (as used by SNLS)

2 steps : light-curve fitting without distance information (can use high-z SNe for training), distance estimate with a combination of the parameters

Full model of the spectral sequence  
- integrated spectrum compared to data  
-> better error propagation

The relation between the measured color and the luminosity is fitted at the same time as cosmology.

In SNLS, for each SN, three parameters are derived :

- magnitude ( $m_B^*$ ), stretch (s), and a color (c)
- no prior is applied
- the distance estimate is a linear combination of those parameters:

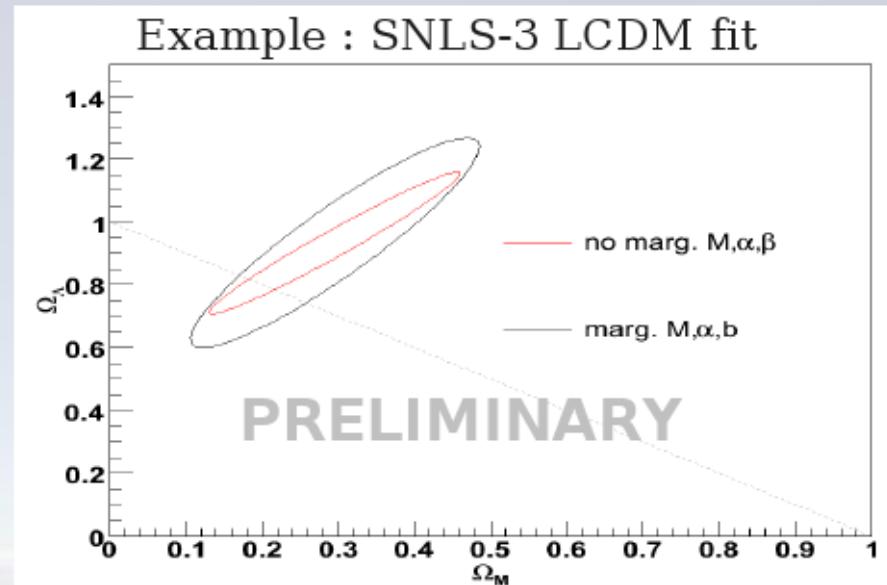
$$\mu_B = m_B^* - M + \alpha(s - 1) - \beta c \quad (\text{sufficient to describe the data})$$

- coefficients  $\alpha$  and  $\beta$  are fitted at the same time as cosmology  
( and marginalized over, same for M )
- we find  $\beta \sim 2$  (+- 0.2)

#### Criticism :

"c is a single parameter that mixes intrinsic color and dust reddening.  
Hence, evolution of the ratio of the two with z may change the value of  $\beta$ "

-> one can fit a correction :  
 $-(\beta_0 + \beta' z)c$



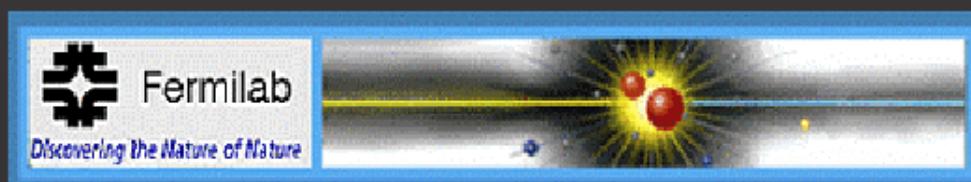
## Challenges for SNe cosmology

- 1) SNe phenomenology : the unfolding of the effects of intrinsic color variation and dust extinction reddening is needed
- 2) When treated correctly, uncertainties due to k-correction (SN model), dust or SN evolution with redshift scale down with the size of the survey (number of SNe)
- 3) Calibration will be the dominant source of uncertainty for future large projects ( $\sim 0.1\%$  required)
- 4) Short term priority of SNe cosmology is now low z surveys :
  - improved statistics
  - improved calibration
  - control of selection bias
  - better understanding of SNe diversity

# Cosmology with the Sloan Digital Sky Survey: a Biased Sampling

Josh Frieman

Moriond Conference, Mar. 16, 2008



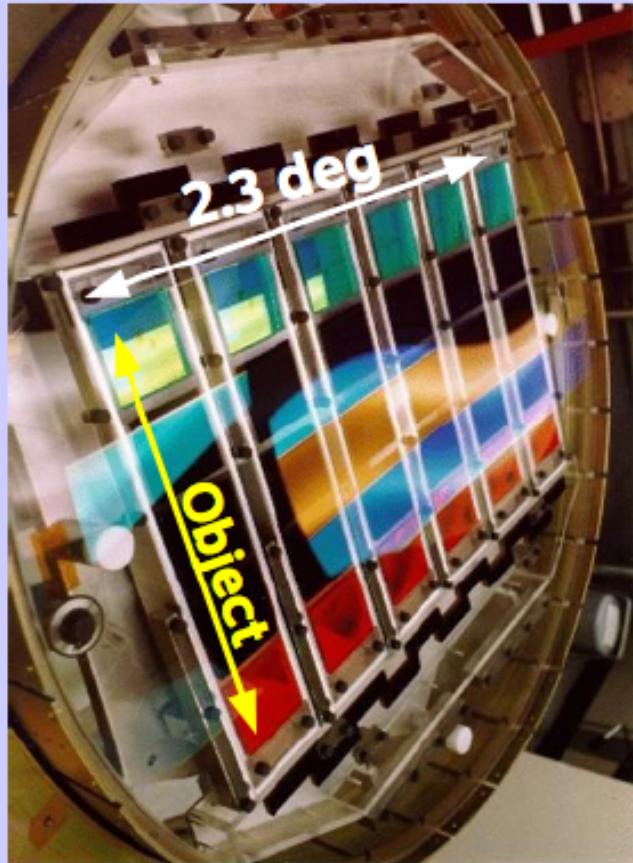
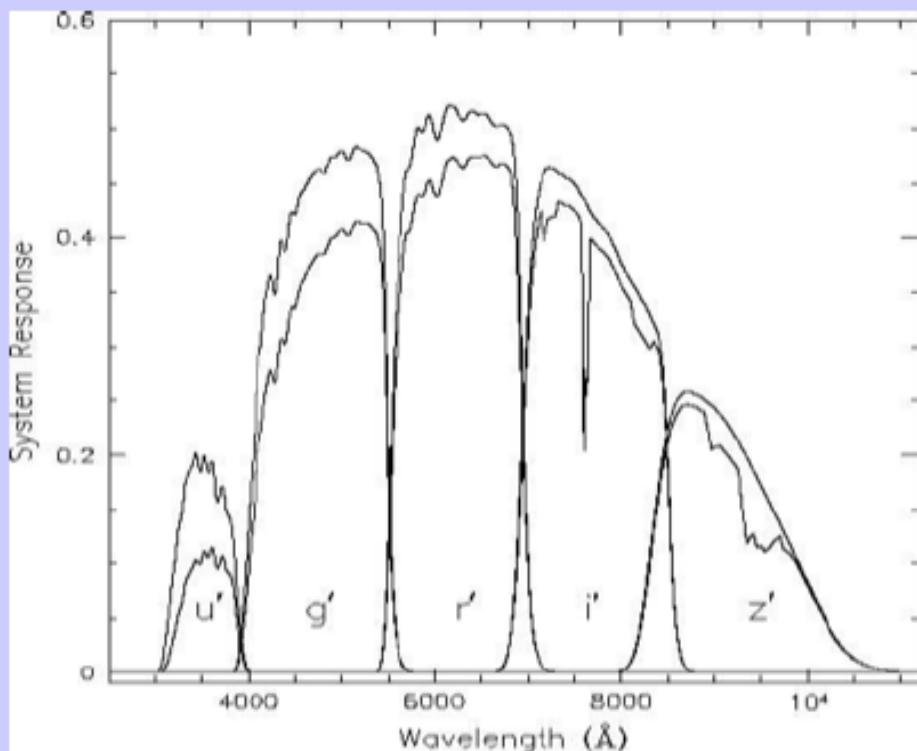
SDSS 2.5 meter telescope  
Apache Point Observatory  
New Mexico

SDSS-I: 2000-5  
SDSS-II: 2005-8  
SDSS-III: 2008-14



# SDSS-2.5m Imaging Camera

- drift scan camera  
(30 2048 x 2048 TectronixCCDs)
- 5 filters in r i u z g
- siderial scan rate
- integration time 56 s



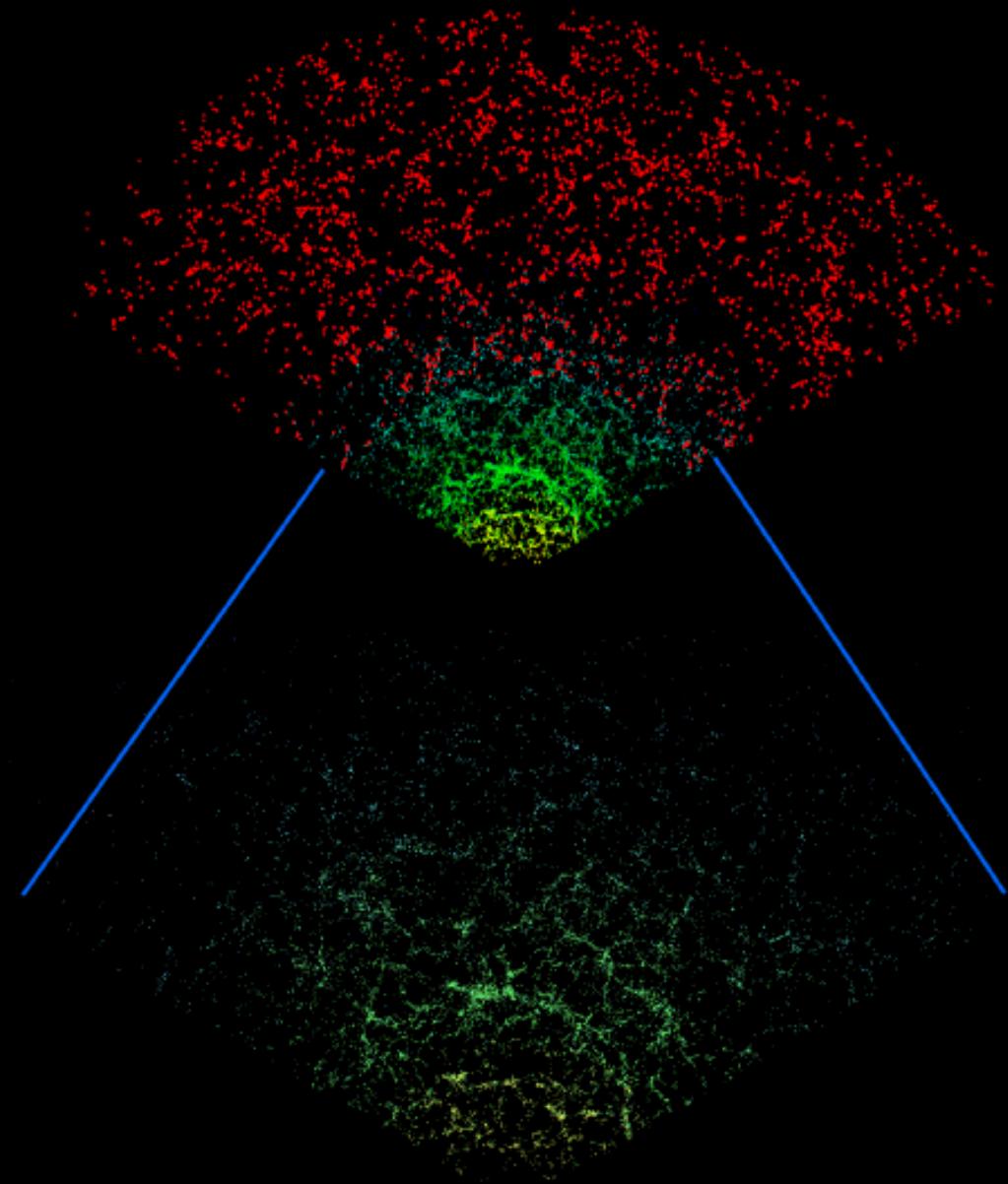
u	g	r	i	z
22.0	22.2	22.2	21.3	20.5

(56s, 95%, stars)

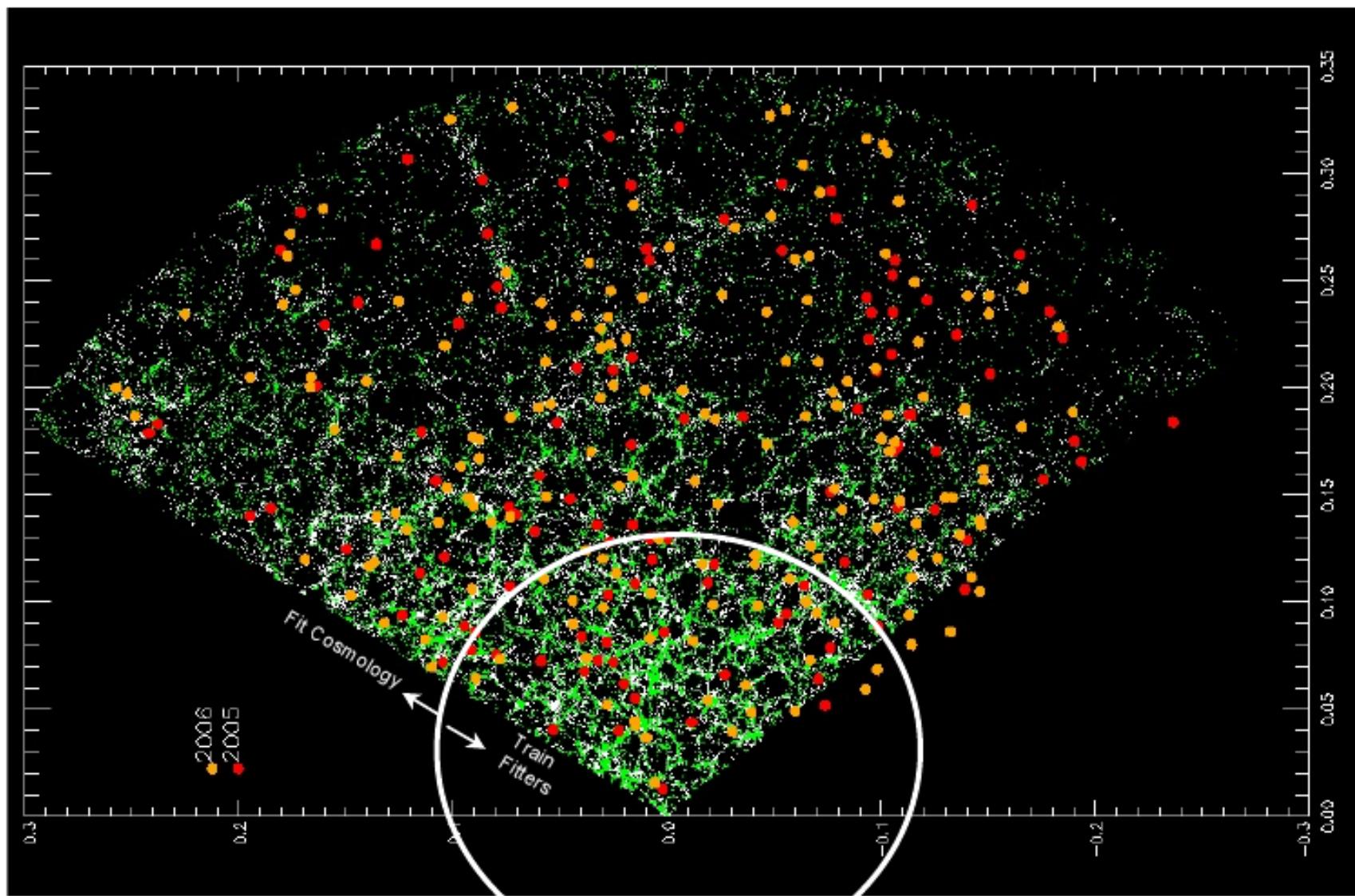
# Redshift Surveys

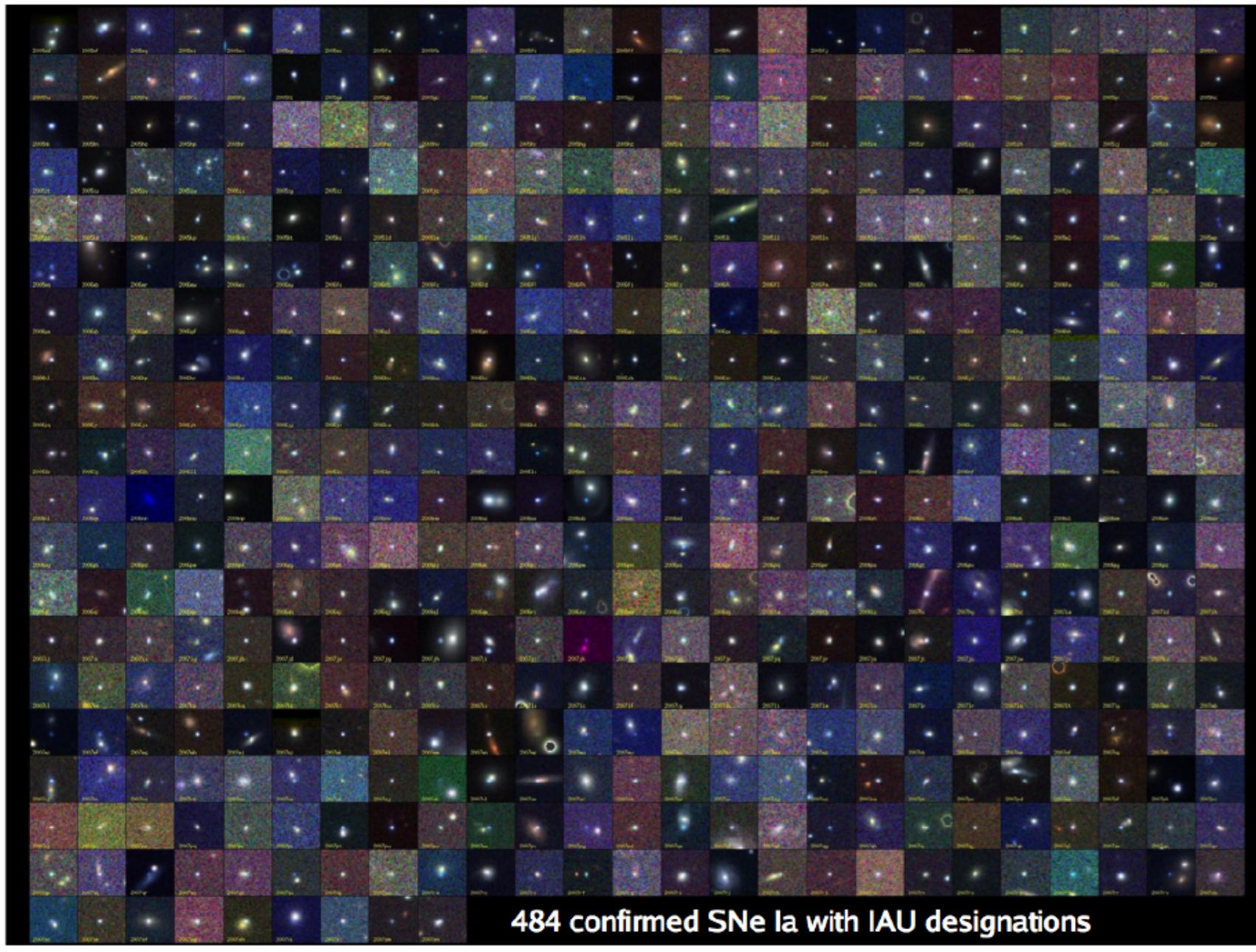
Luminous  
Red  
Galaxies  
 $z \sim 0.3$   
sparse  
sampling

Main  
Sample  
Galaxies  
 $z \sim 0.1$



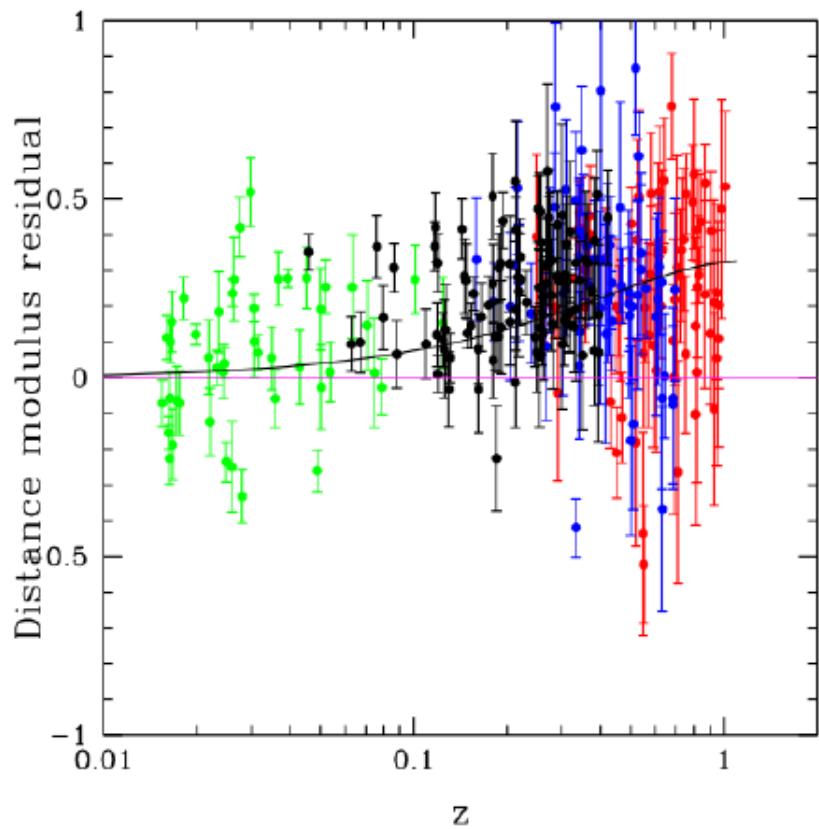
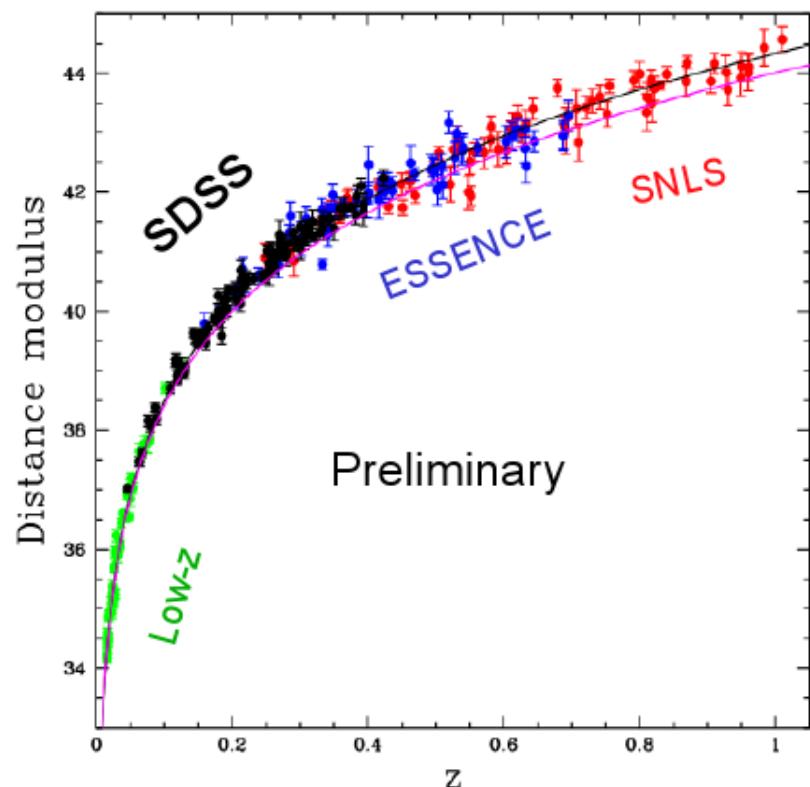
# Future: Improved SN Ia Distances





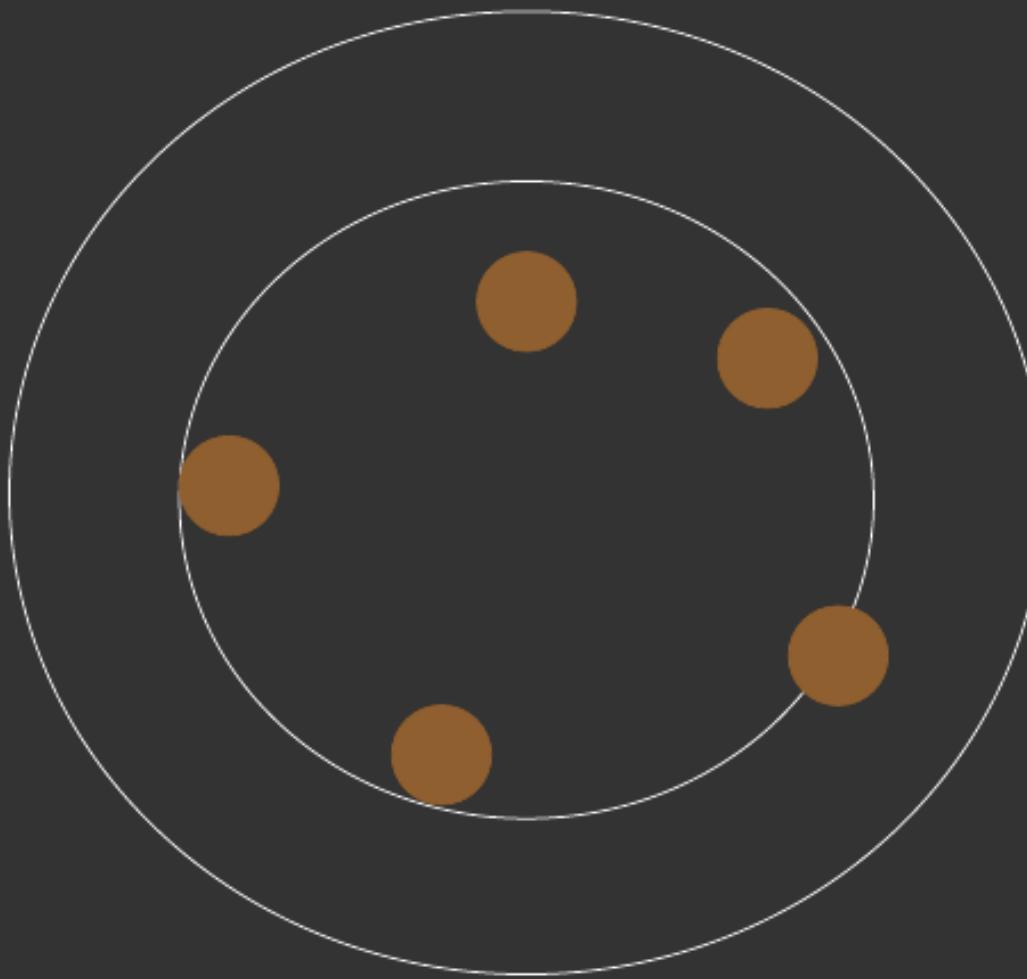
484 confirmed SNe Ia with IAU designations

# Hubble Diagram



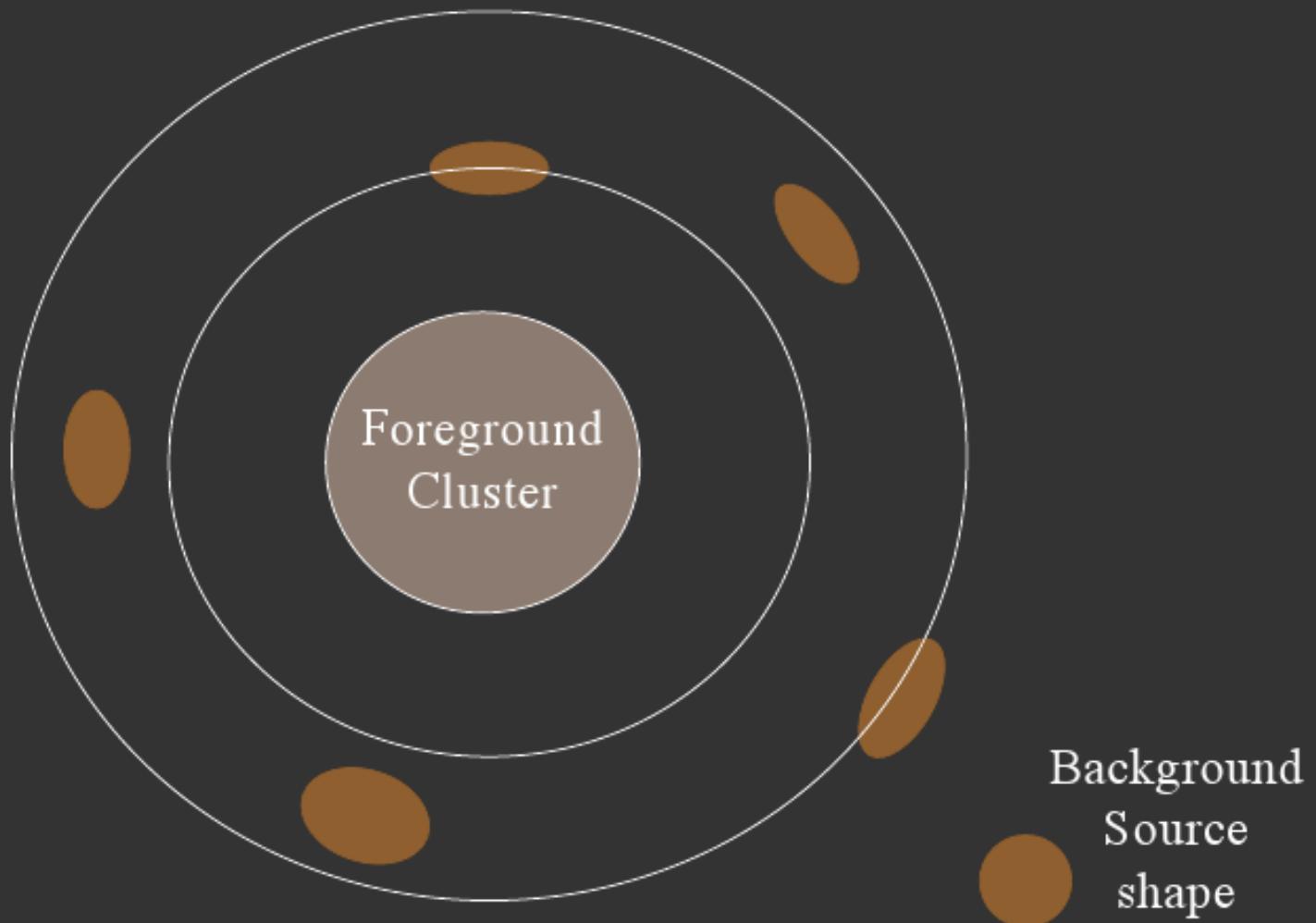
- SDSS 2005 Data only
  - 130 SNe Ia
  - 99 after quality cuts
  - Kessler et al (2008) to appear

## Weak Lensing of Faint Galaxies: distortion of shapes



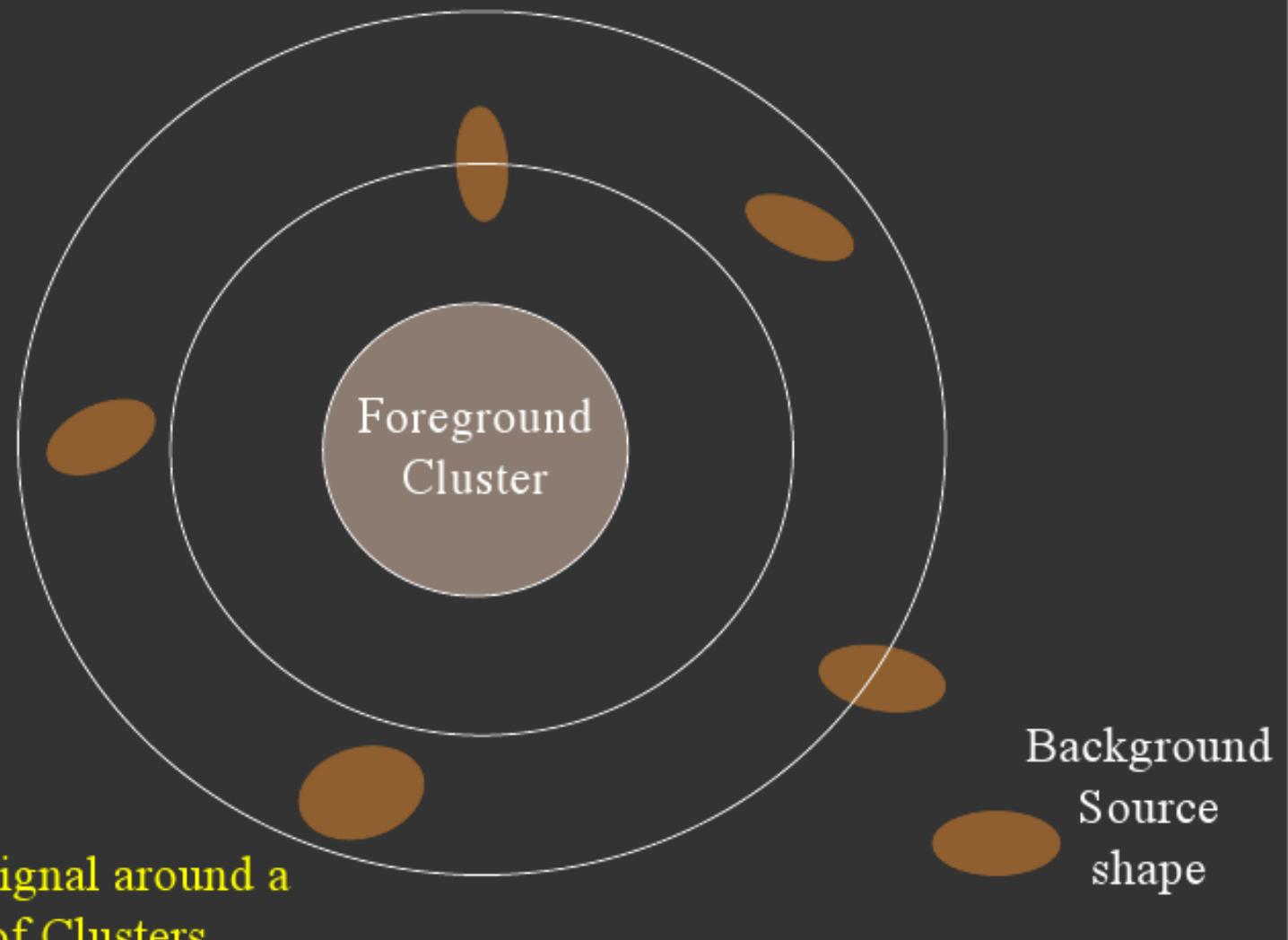
Background  
Source  
shape

## Weak Lensing of Faint Galaxies: distortion of shapes



Note: the effect has been greatly exaggerated here

## Lensing of real (elliptically shaped) galaxies



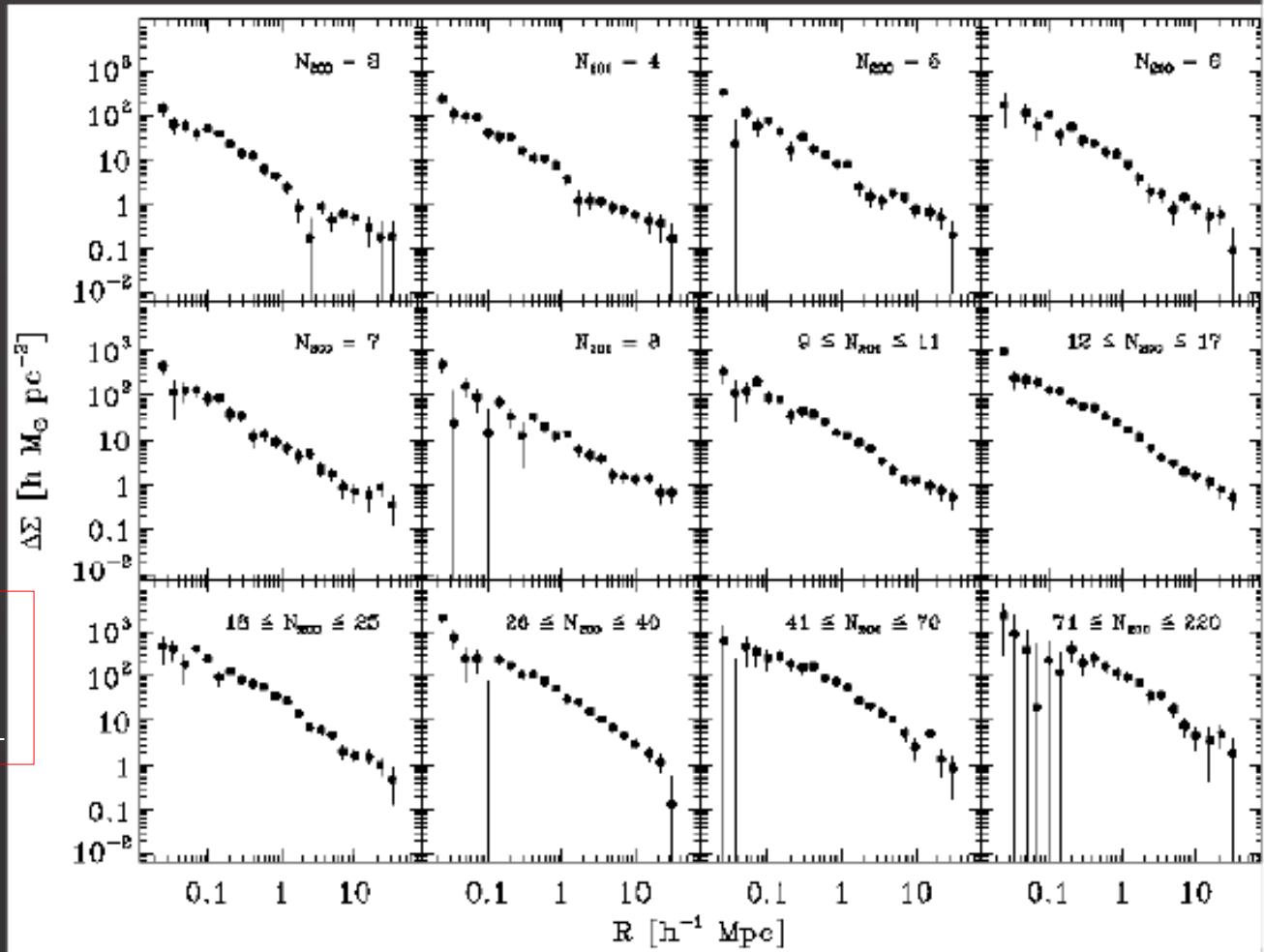
# Statistical Weak Lensing by Galaxy Clusters

Mean  
Tangential  
Shear Profile in  
Bins of Cluster  
Optical  
Richness ( $N_{\text{gal}}$ ),  
measured to  
 $30 h^{-1} \text{ Mpc}$

$$\Delta\Sigma(R) = \gamma_T(R) \times \Sigma_{\text{crit}}$$

$$\Sigma_{\text{crit}} = c^2 D_s / 4\pi D_{\text{LS}} D_L$$

Sheldon, et al 2007



# Decelerating and Dustfree: Dark Energy Studies of Supernovae with the Hubble Space Telescope

Kyle Dawson  
March 16, 2008

For the SuperNova Cosmology Project

# The Problem with Dust

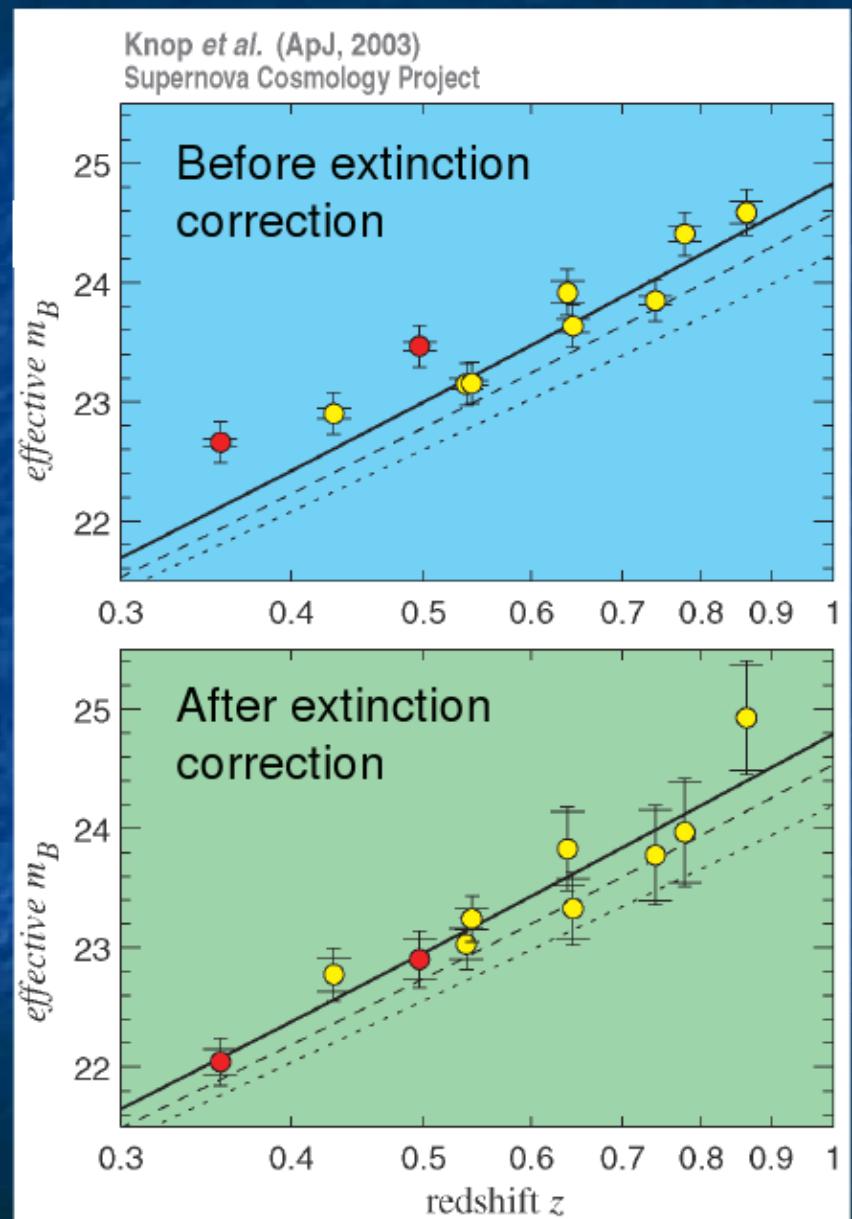
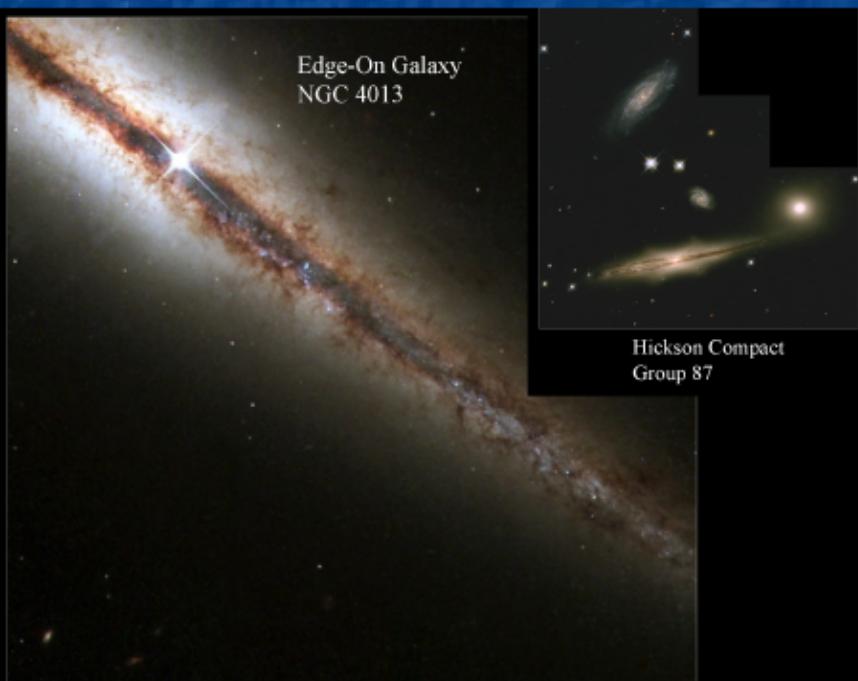
## Host galaxy dust extinction

If host galaxy is similar to Milky Way then:

$$\Delta M_B = R_B E(B-V) \text{ with } R_B \sim 4$$

Color error  $\sim 0.1 \Rightarrow$  Magnitude error  $\sim 0.4$

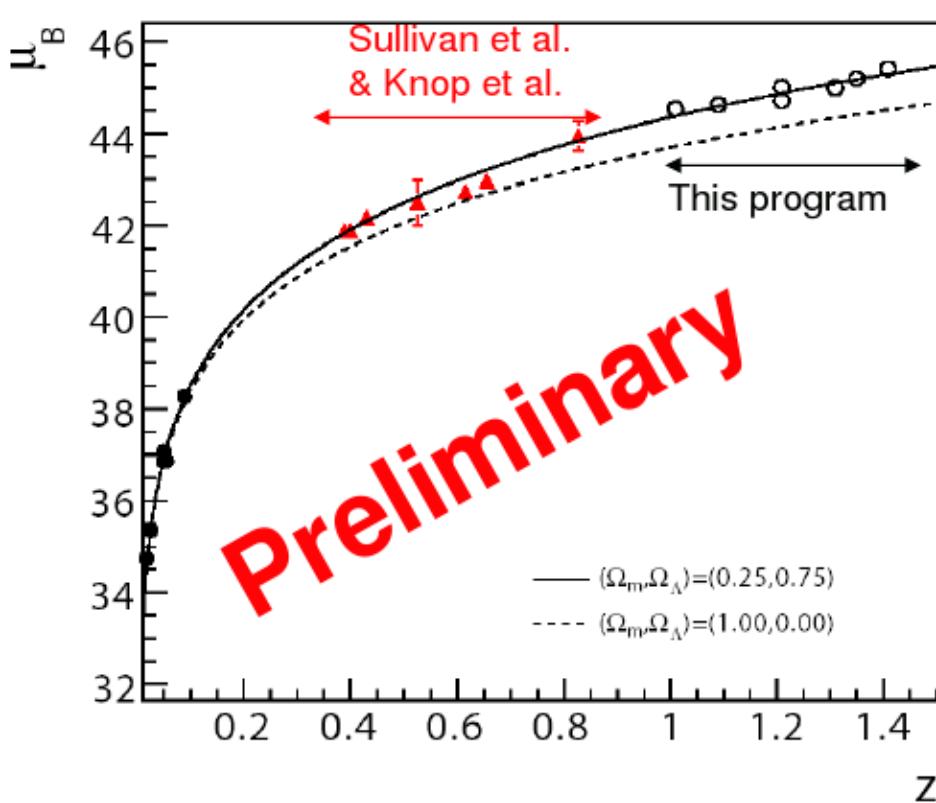
**Extinction correction dominates measurement error!**



# The Elliptical host (E/S0) Hubble Diagram

## No extinction correction

Example of E-only Hubble Diagram



(David Rubin)

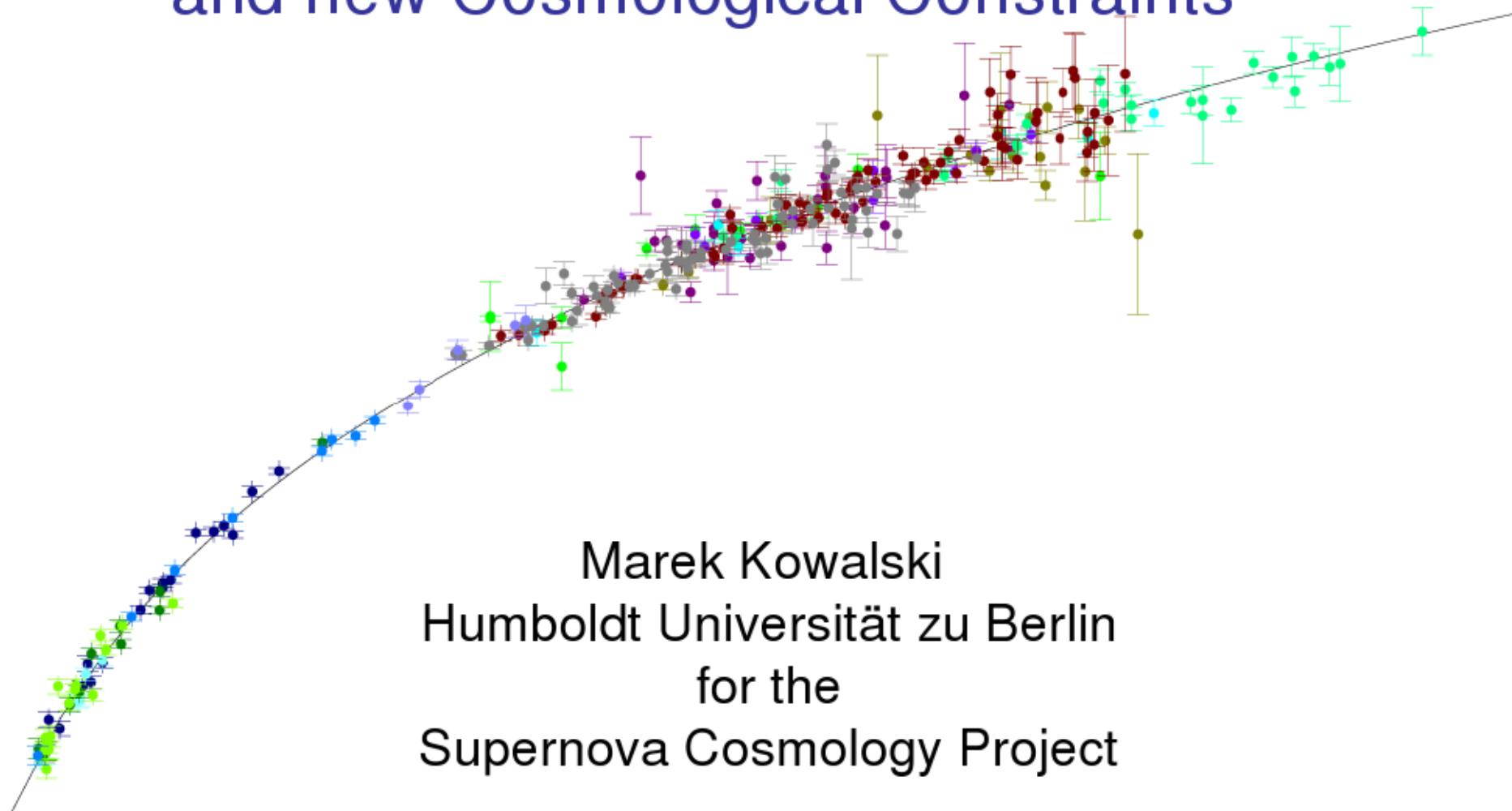
Seven SNe Ia in elliptical galaxies observed with complete lightcurves.

No extinction correction applied

other analyses

- SN Ia rate in cluster environment
- Host Properties
- Cluster studies (collaborators)
- Weak lensing
- Red Sequence Scatter
- Etc.

# The “Union” Supernova Ia Compilation and new Cosmological Constraints



Moriond 2008

# Equation of state: $w = p/\rho$

## SNe + BAO + CMB

$$w = -0.969 \pm 0.061(\text{stat}) \pm 0.065(\text{sys})$$

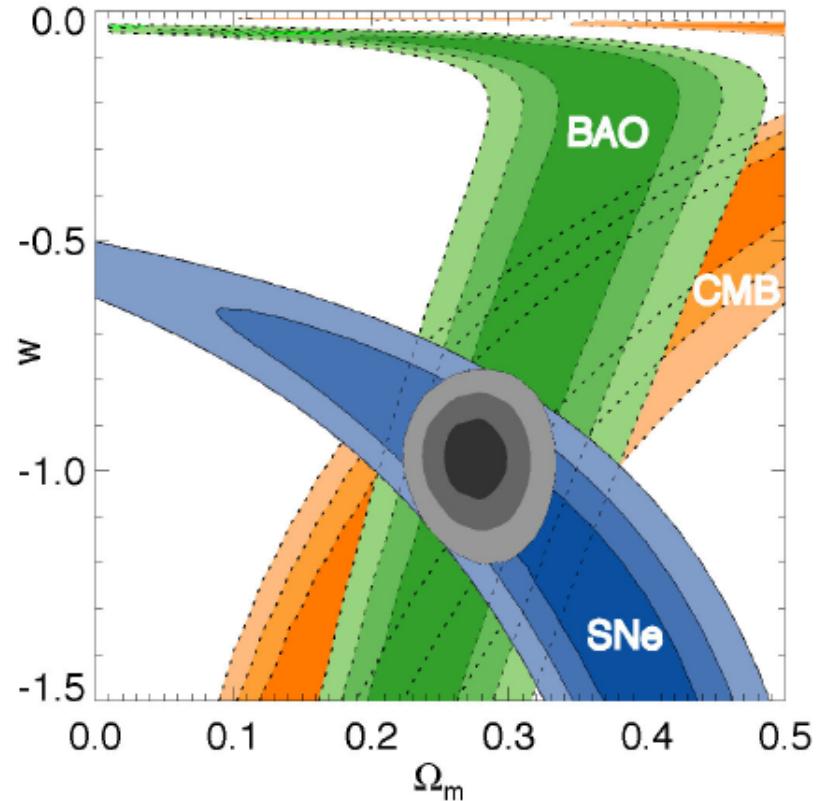
... and allowing for curvature:

$$w = -1.001 \pm 0.071(\text{stat}) \pm 0.081(\text{sys})$$

Resolution of Carlos' question in Steve's talk last week:

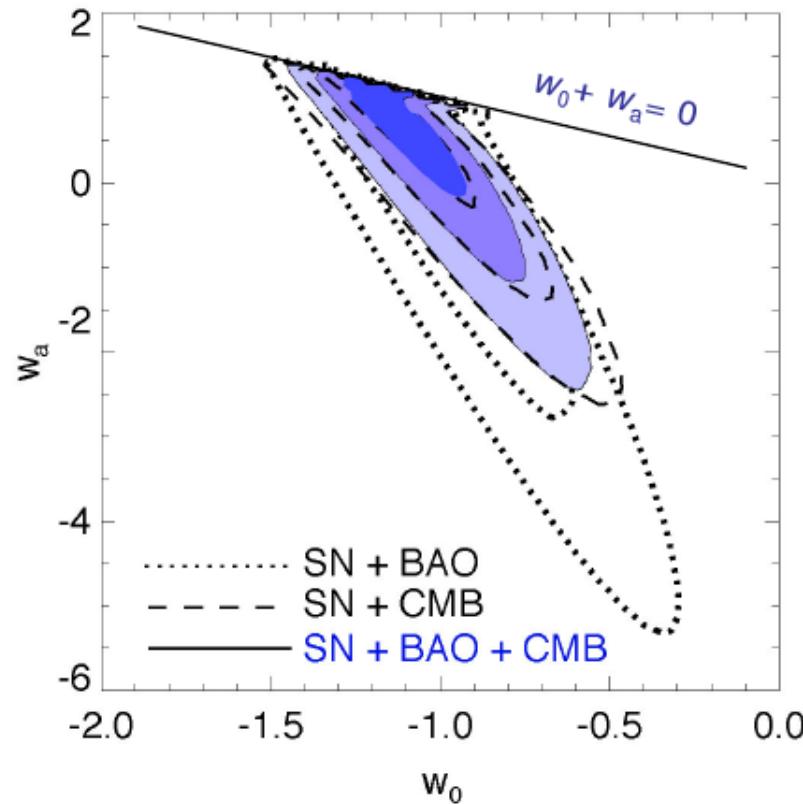
1) this is 1 standard deviation,  
Steve's curves are 2 sigma = 95%

2) this fit assumes  $w_a = 0$ ; relaxing  
this more than doubles the error on  $w_0$



# Redshift dependent $w$

$$w = w_0 + (1-a) w_a$$





# *Dark Energy Survey Supernovae*

## *Simulations and Survey Strategy*

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Joseph P. Bernstein

HEP Division, Argonne National Lab, U.S.A.

43<sup>rd</sup> Rencontres de Moriond, La Thuile, Italy, 20 March 2008

Co-authors: Richard Kessler (U. Chicago, U.S.A.), Stephen  
Kuhlmann (Argonne, U.S.A), Harold Spinka (Argonne, U.S.A.)



# Outline

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- Introduction
- Light curve simulator & fitter
- Bias studies
- Survey figure of merit
- Summary & conclusions



DARK ENERGY  
SURVEY



University of Chicago

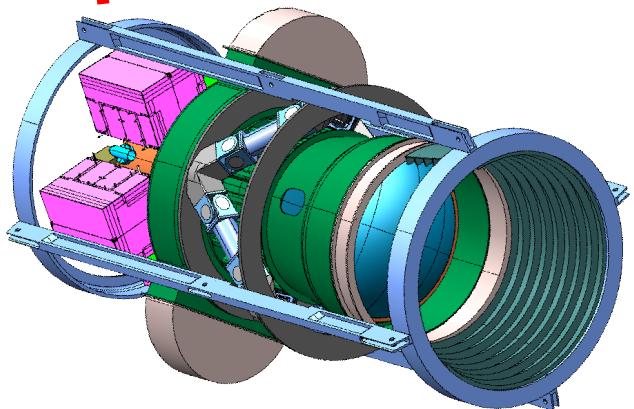
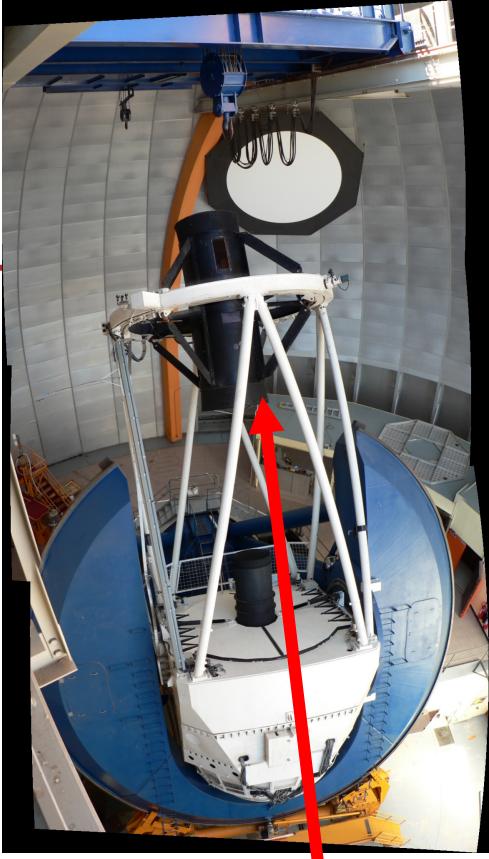


# Dark Energy Survey (DES)

DES is providing a new 520Mpixel CCD camera (DECAM) for the Blanco 4m telescope in Chile in exchange for 525 survey nights over 5 year period

DES group at Argonne:

Joe Bernstein, Steve Kuhlmann, Hal Spinka,  
& Rich Talaga, plus Vic Guarino & Allen Zhao





# Dark Energy Survey (DES) Supernovae

- DES time allocation fixes total supernovae (SNe) exposure time
  - 1000 hr planned over 5-year survey period
  - maximal use of non-photometric time (~500 hr) planned
- Time per field & number of fields can be simulation optimized
  - Ultra-deep strategy (3 square degrees = 1 DES field)
  - Deep strategy (9 square degrees)\*
  - Shallow but wide strategy (27 square degrees)
  - or a hybrid approach
- Total DES survey is 5000 square degrees

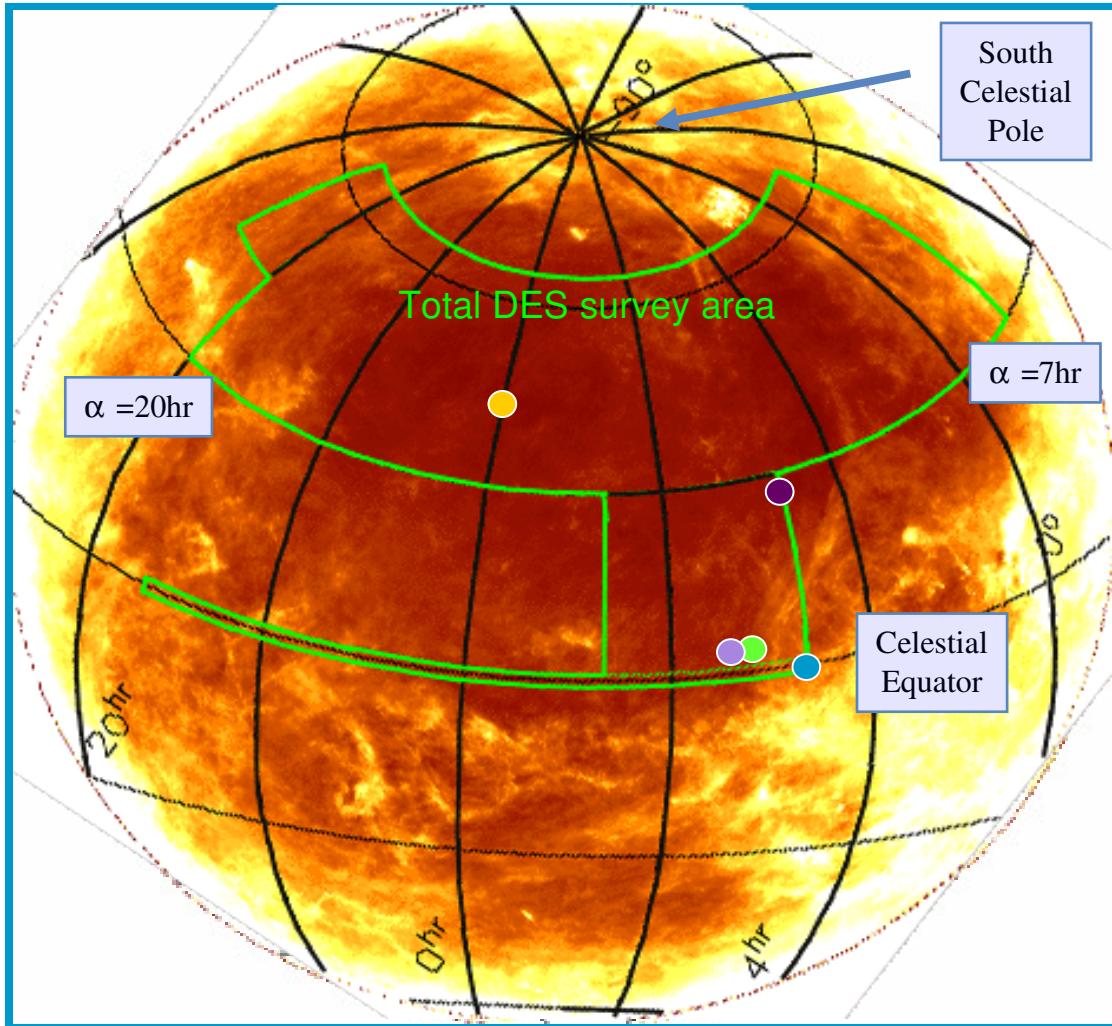
\* Highlighted in DES DOE proposal.

# Current Favored DES Supernova Fields

- Chosen to maximize:
  - visibility from DES site
  - past observation history
  - visibility from, e.g., Hawaii

Chandra Deep Field – South ●  
Sloan Stripe 82 ●  
SN Legacy Survey (SNLS) D1 ●  
XMM-Newton LSS ●  
ELAIS S1 ●

From a study by Peter Nugent



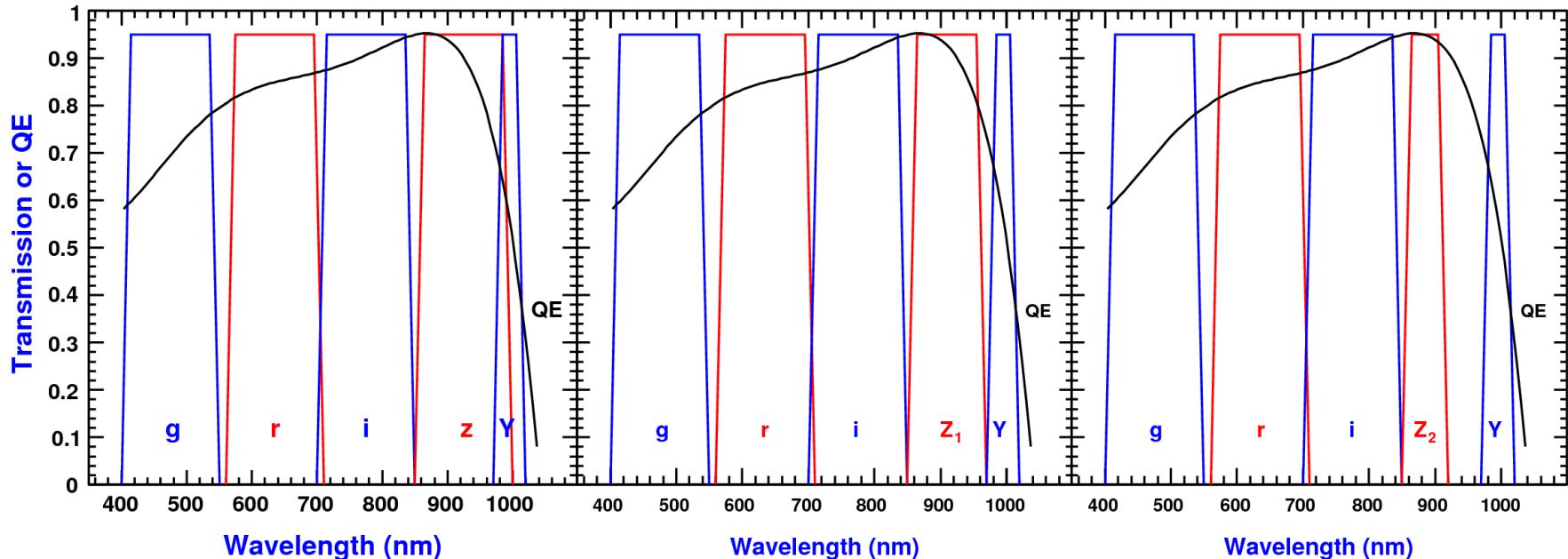


# Spectroscopic Strategy

- Spectroscopy of full SNe sample?
  - expensive (large-telescope observing time)
  - plan is follow-up for ~25% of SN sample
  
- Full host galaxy follow-up more feasible
  - negligible redshift errors ( $\Delta z < 0.001$ )
  - redshift critical for distinguishing type Ia & II SNe



# DES Filters

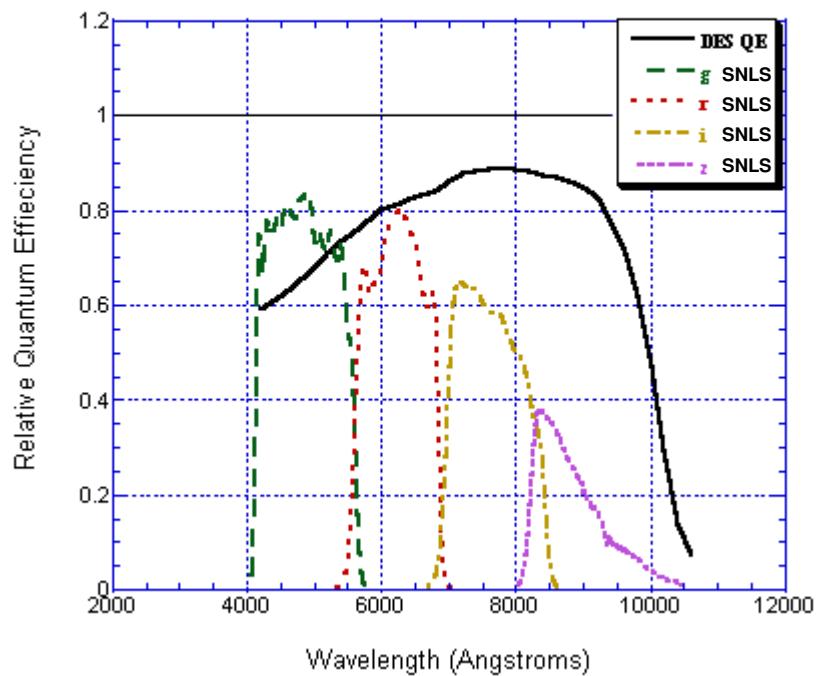


## ■ Filters: g, r, i, z or $Z_1$ or $Z_2$ , Y ?

- Deep exposure times ~300s, 600s, 1800s, 1667s, 2333s in g, r, i, z, Y ?
- longer/shorter for ultra-deep/wide surveys (total time fixed)
- cadence: 6-8 days worst case, 3-4 days typical?

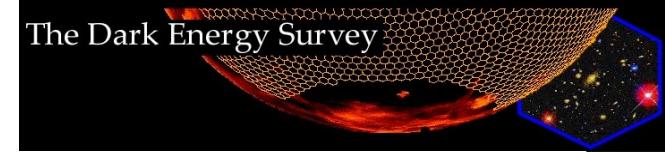


# DES vs. SNLS: Quantum Efficiency



The DES uses thicker LBNL CCDs with increased sensitivity at redder wavelengths

Plot courtesy of John Marriner



# SNANA Software Package for DES

R. Kessler (U. Chicago), J. P. Bernstein, S. Kuhlmann, & H. Spinka (ANL)

- Software suite for simulating and fitting SN light curves
- Publicly available: [http://www.hep.anl.gov/des/snana\\_package](http://www.hep.anl.gov/des/snana_package)
- Goal: an accurate and complete study of DES Supernovae capabilities including DES CCD & filter characteristics, Cerro Tololo Inter-American Observatory (CTIO) sky fluctuations using data inputs from the ESSENCE SN survey, dust extinction effects, etc.
- Also used by other projects
  - Sloan Digital Sky Survey (SDSS)
  - Large Synoptic Survey Telescope (LSST) SN project



# Simulator Description

- Computes rest-frame model magnitudes using various models
- Applies random color/luminosity fluctuations
- Includes host galaxy dust extinction
- Applies K-corrections
- Offers a choice of cosmologies
- Applies Milky Way dust extinction via Schlegel maps\*
- Uses survey zero-points to convert magnitudes to flux
- CCD gain, noise, and sky noise added

Fitter included for resulting light curves

\*Schlegel, Finkbeiner, Davis 1998, ApJ, 500, 525



# Multi-color Light Curve Shape Model

(MLCS2k2; Jha, Riess, Kirshner 2007, ApJ, 659, 122)

- Light curve model magnitude  $m_x$  for passband  $x$  at given epoch:

$$m_x = M_x + \mu_0 + \Xi_{x,MW} + \Xi_{x,H}(R_v, A_{v0}) + P_x \Delta + Q_x \Delta^2$$

- 4 free parameters:

- $t_0$ : epoch of maximum light in B-band
- $\mu_0$ : distance modulus
- $\Delta$ : luminosity/light curve shape parameter
- $A_{v0}$ : extinction in magnitudes by host dust;  $R_v = A_{v0} / E(B-V)$ , initially set to 3.1\*

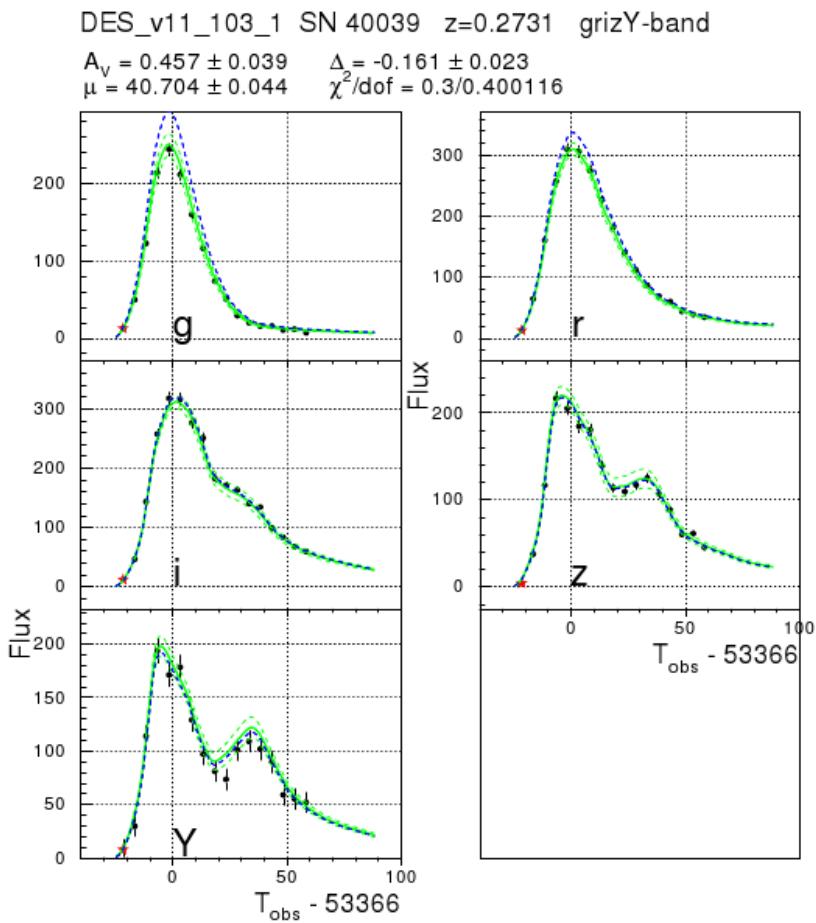
- Provided by MLCS2k2 SN data training (Jha,Riess,Kershner 2007):

- $M_x$ : rest-frame magnitude w/  $\Delta = A_{v0} = 0$
- $P_x$  &  $Q_x$ : describe change in shape & luminosity as function of  $\Delta$
- $\Xi_x$ : extinction functions; “MW” for Milky Way & “H” for host galaxy

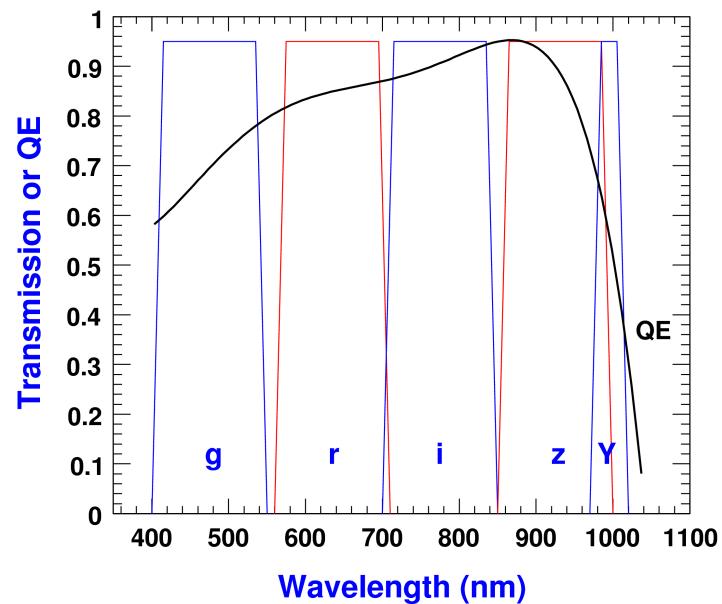
\* Cardelli, Clayton, Mathis 1989, ApJ, 345, 245, and references therein

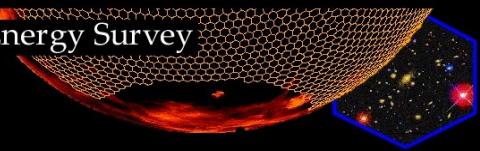


# Simulated DES Light Curves

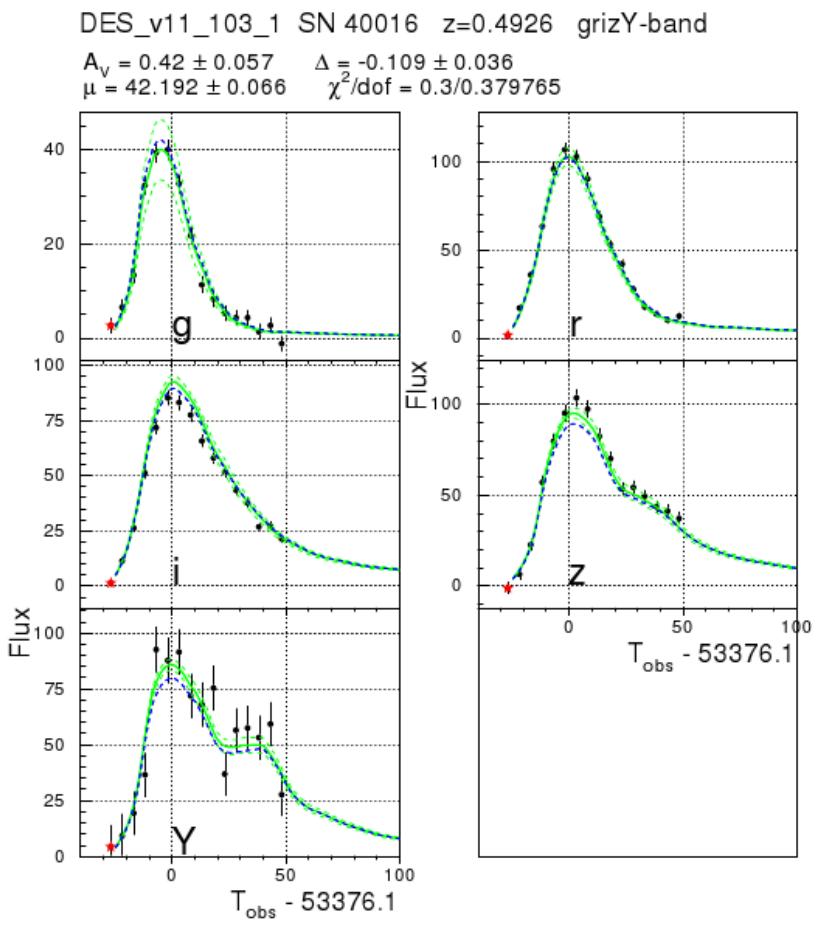


Example light curve at  $z \sim 0.27$  for a deep survey (9 sq. deg.) using the grizY filter set. 2nd bump unique to SN type Ia.

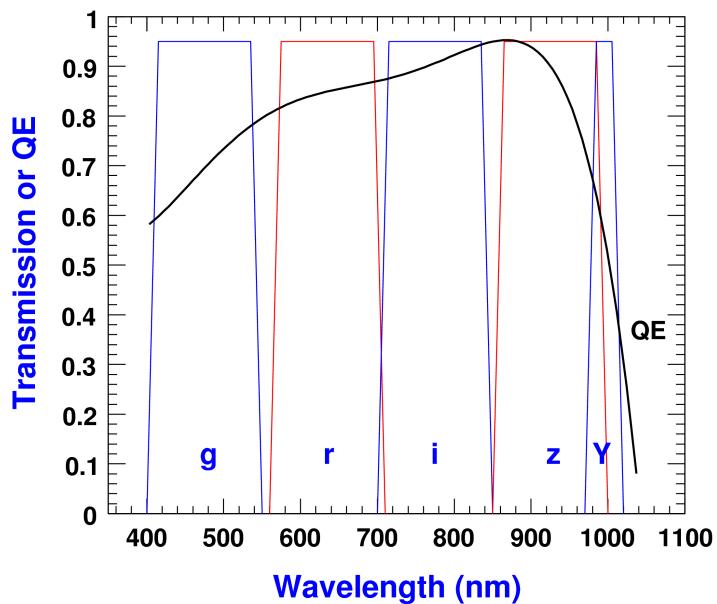




# DES Light Curves

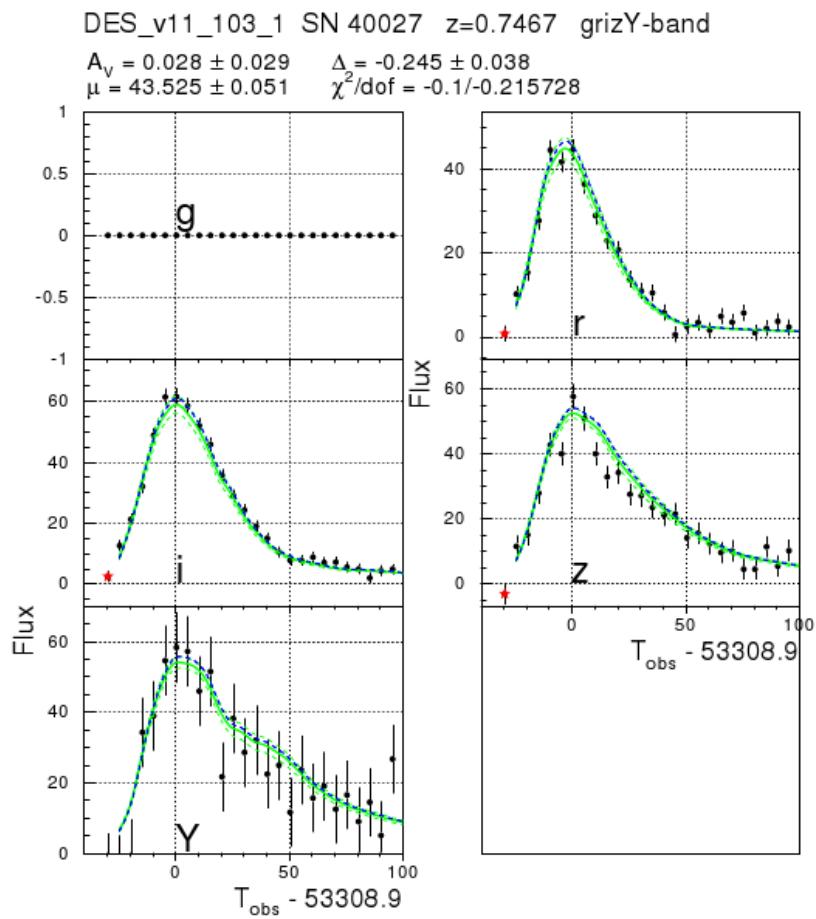


Example light curve at  $z \sim 0.49$  for a deep survey (9 sq. deg.) using the grizY filter set.

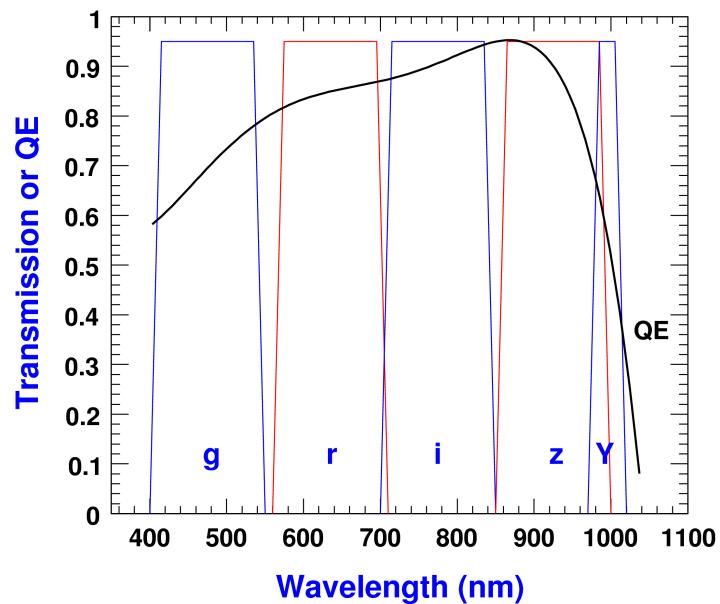




# DES Light Curves

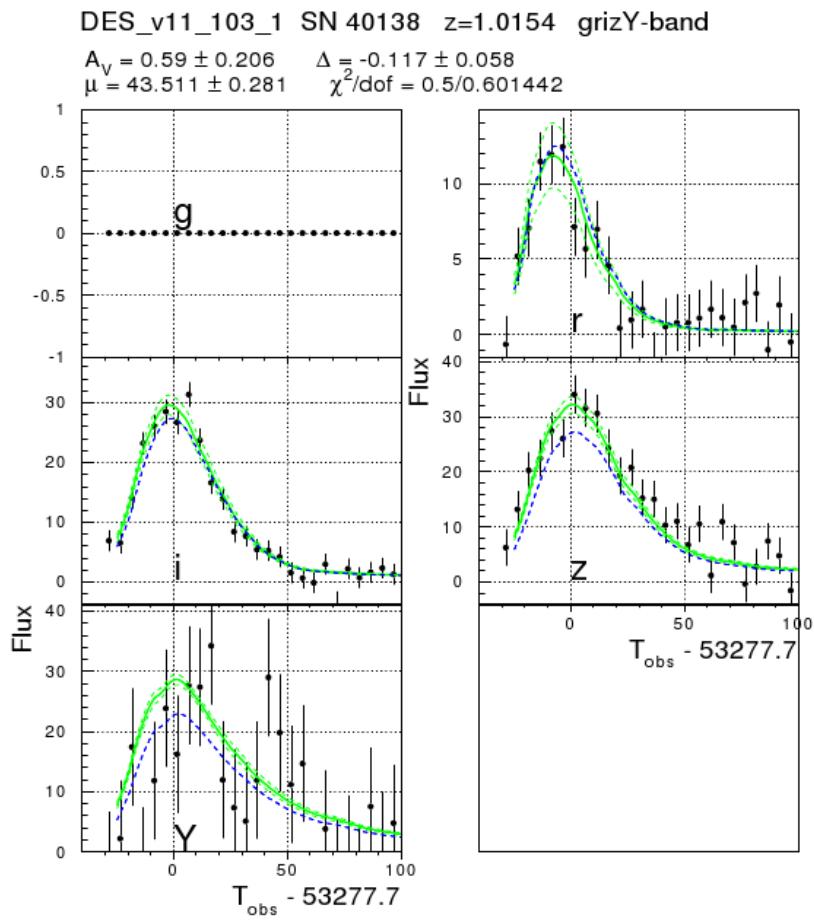


Example light curve at  $z \sim 0.75$  for a deep survey (9 sq. deg.) using the grizY filter set.

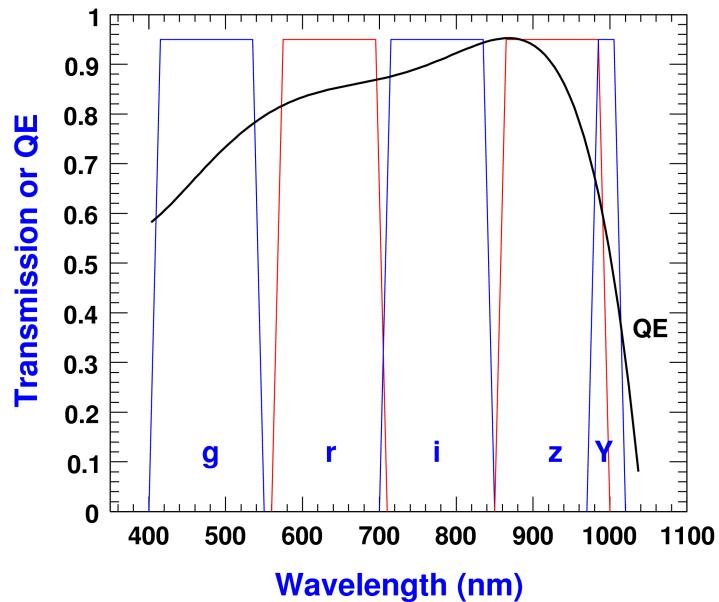


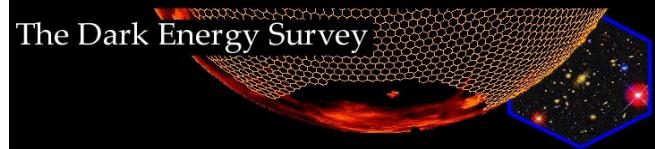


# DES Light Curves



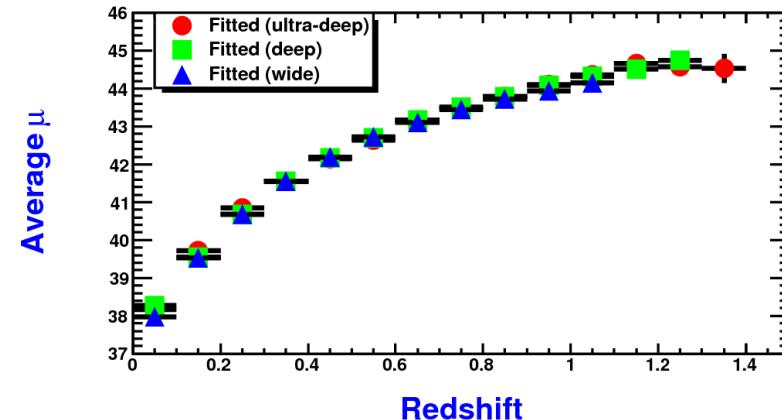
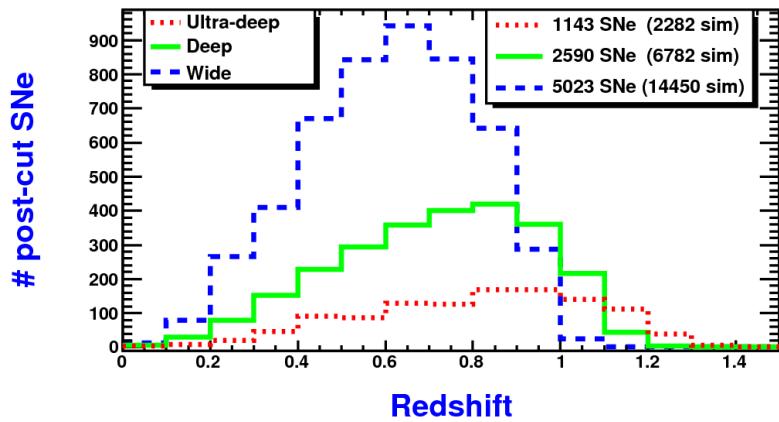
Example light curve at  $z \sim 1.0$  for a deep survey (9 sq. deg.) using the grizY filter set.



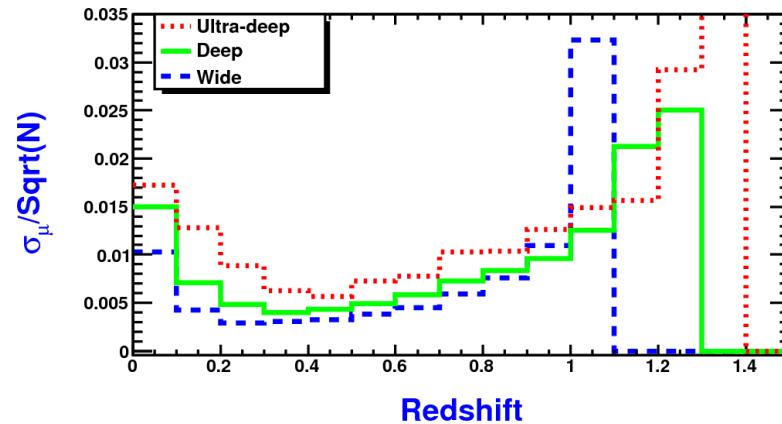


# Number of SNe & Statistical Distance Error

Cuts of 1 filter  $> 10$  and any 3  $> 5$  S/N have been applied for the grizY filter set



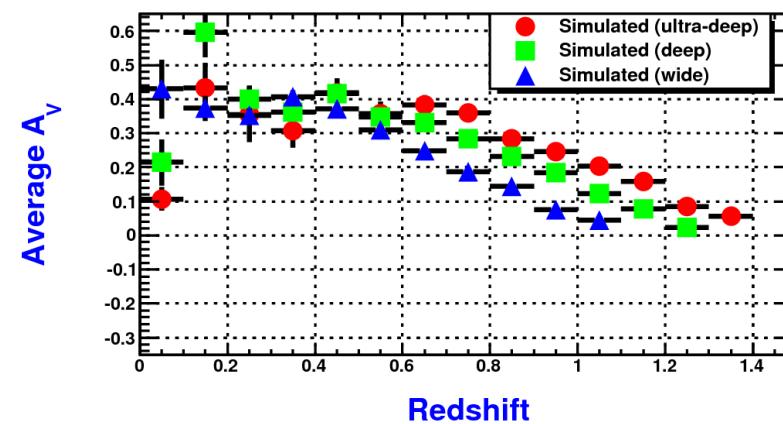
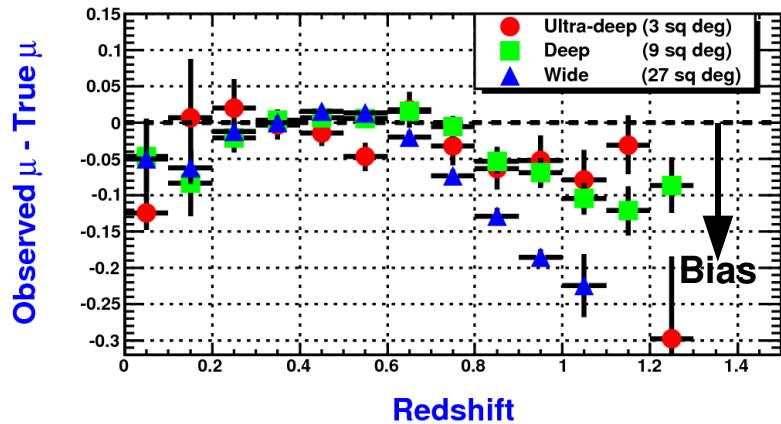
Error on the Hubble diagram for ultra-deep, deep, & wide surveys  
(3, 9, 27 sq. deg., respectively)



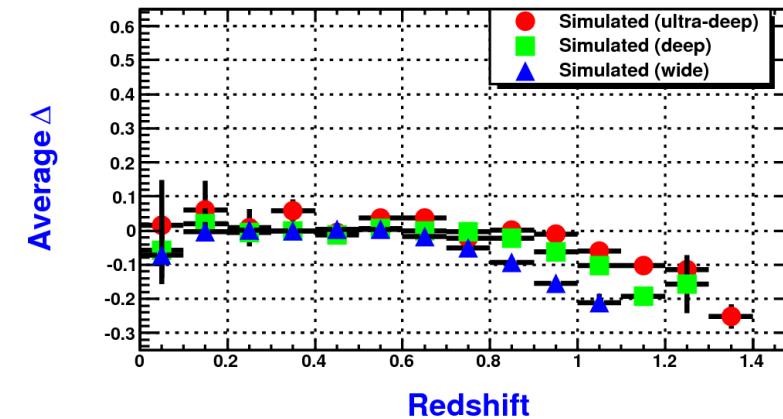


# Sensitivity of $\mu$ to Extinction Priors

Cuts of 1 filter > 10 and any 3 > 5 S/N have been applied for the grizY filter set



A bias in  $\mu$  is evident in the difference in the fitted and simulated values, arises from selection efficiencies not being taken into account, and illustrates the magnitude of the  $\mu$ -correction that will be needed

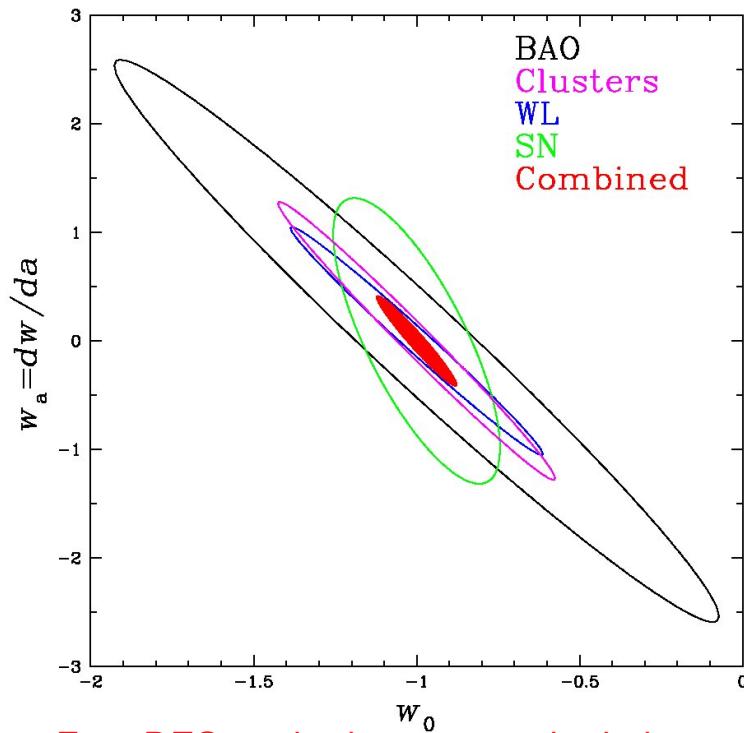


Recall:  $A_v = 3.1 \times E(B-V)$



# DES Figure of Merit (FoM)

- Dark Energy Task Force (DETF) FoM: inverse size of  $w_a - w_o$  error ellipse
  - $w(a) = w_o + (1-a)w_a$
  - $a$  = scale factor
  - $w_o$  =  $w$  at present epoch
  - $w_a$  = rate of change of  $w$  with  $a$
- Systematic effects to consider:
  - light curve model
  - dust extinction vs. intrinsic color
  - photometric calibration
  - non-1a background
- DES survey strategy emphasizes best FoM + control of above systematics



Four DES methods to constrain dark energy  
(plot from NSF/DOE proposal including Planck priors but NOT the DETF Stage II constraints)



# DES FoM

Method	$[\sigma(w_a)\sigma(w_p)]^{-1}$
BAO	72.8
Clusters	152.4
Weak lensing	155.8
Supernovae	107.5
Combined DES	263.7
DETF Stage II combined	57.9

Projection from NSF/DOE proposal

N.B.:  $w_p = w(a_p)$  where  $a_p$  minimizes the error in  $w$  for given model. The area of the error ellipse in the  $w_p - w_a$  plane equals the area in the  $w_0 - w_a$  plane  $\Rightarrow$  DETF FoM  $\propto [\sigma(w_a)\sigma(w_p)]^{-1}$   
(DEFT Final Report, 2006)

DES offers an improvement on the DETF Stage II constraints by factor of 4.6

Currently working on using a cosmology fitter to calculate simulated FoM from SNANA light-curve fits

# DES FoM, con't



Used Sussex fitter (plus changes by Marriner) to compute DETF FoM – Stage II constraints include 500 low-z anchor so currently no additional low-z SN added

Statistics only!

All runs without low z sample			
Sq. deg.	Run	Filters	# of SN
3	102	grizY	1100
9	103	grizY	2590
27	104	grizY	5045
3	202	griZ <sub>1</sub> Y	1099
9	203	griZ <sub>1</sub> Y	2583
27	204	griZ <sub>1</sub> Y	4931
3	302	griZ <sub>2</sub> Y	1103
9	303	griZ <sub>2</sub> Y	2444
27	304	griZ <sub>2</sub> Y	4190
3	402	griz	1115
9	403	griz	2635
27	404	griz	5118

27 sq. deg.  
best

(Table by R. Reis)

Hybrid survey (2 deep fields+3 shallow) gives FoM similar to 27 sq deg





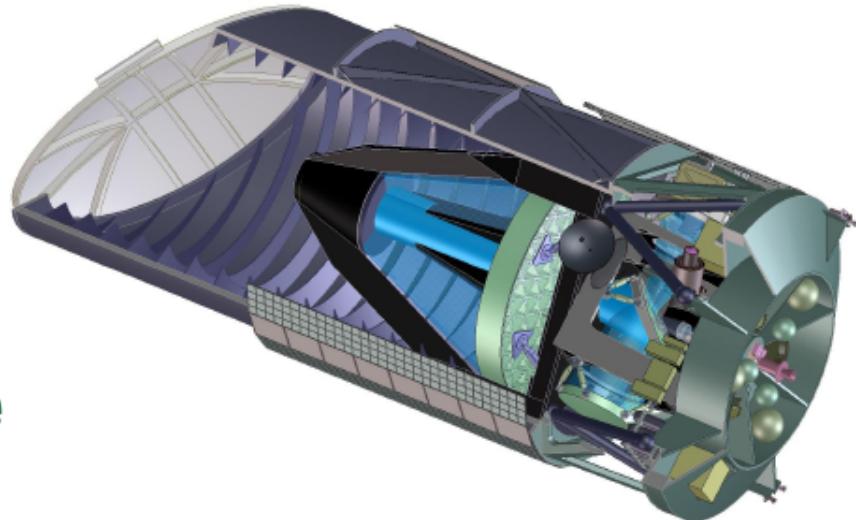
# Summary & Conclusions

- DES simulates SN light curves via realistic SNANA package
- Light curves harnessed to study effects of:
  - survey depth (ultra-deep vs. deep vs. wide)
  - choice of filter sets & exposure times
  - cadence including weather
  - magnitude of a selection bias
  - color systematics including fitting  $A_v/R_v$  instead of fixing  $R_v$
- With FoM simulation  $\Rightarrow$  constraint on optimal survey strategy
- Ultimately: strategy whitepaper & (possibly) bias studies paper



# SNAP-L

**Probing the nature  
of dark energy..**



A.EALET

CPPM/IN2P3

*On behalf the SNAP collaboration*

# JDEM



- Nov 2003 JDEM Announcement from DOE & NASA
- Feb 2005 Nat'l Academy Sciences: Cmt. on Astro.& Astrophys. reaffirms priorities.
- Aug 2006 NASA selects advanced mission concept studies (ROSES). SNAP, ADEPT, DESTINY
- Sep 2007 Nat'l Academy Sciences: BEPAC chooses JDEM.
- March 08 NASA announces the JDEM AO draft in June 08 and final in September 08
  - ⇒ a mission selection for early 09
  - ⇒ a launch expected in 2015



# Mission objectives

Systematic effects are dominant ..=>need simulation + instrument optimisation  
To identify and control all possible effects ..

Supernova	Lensing
standardisation	Theoretical uncertainties on power spectrum
Contamination	Shear calibration
Selection bias	photoZ biases
Evolution/dust	Psf stability
Photometric calibration...	Shape correlation ....

# SNAP surveys



Survey	Area(sq.deg)	Depth(AB mag)	$n_{\text{gal}}(\text{arcmin}^{-2})$	$N_{\text{gal}}$
Deep/SNe	15	30.3	250	$10^7$
Wide	4000	27.8	100	$10^{8.5}$
Panoramic	7000-10000	26.7	40-50	$10^9$

\* and SNAP is in 9 colors!

- Dark energy:
  - SNII
  - baryon oscillations
  - clusters
  - Strong lensing
- Correlation avec ISW, SZ

- ‘other sciences’

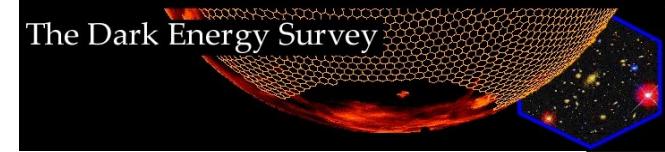
A billion z machine in 9 bands

  - Galaxy evolution
  - Quasars eand AGN
  - Solar system
  - Galaxies, structure
  - High redshifts objects
- ...



# Additional Slides

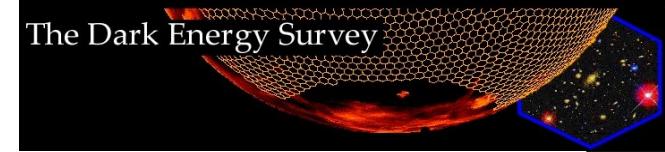
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# DES Zeropoint/Sky Estimates: grizY

(mag = -2.5\*LOG(Flux in ADU) + Zeropt) (1 ADU = 1 e-) (1 arcsec  $\rightarrow$  30.1 Npixels)

	e-/100s for 20th mag	Zeropt for 100s, 100s, 200s, 200s, 200s	SQRT(SKY) for 100s, 100s, 200s, 200s, 200s	Our Limiting Magnitude for 10 sigma for 100s, 100s, 200s, 200s, 200s	Table 8 Vista Proposal (Limiting Mag for 10 sigma)
g	49800	31.7	149	23.8	23.8
r	49400	31.7	236	23.3	23.3
i	36940	32.2	400	23.2	23.3
z	38000	32.2	735	22.5	22.6
Y	7600	30.5	520	21.2	21.2



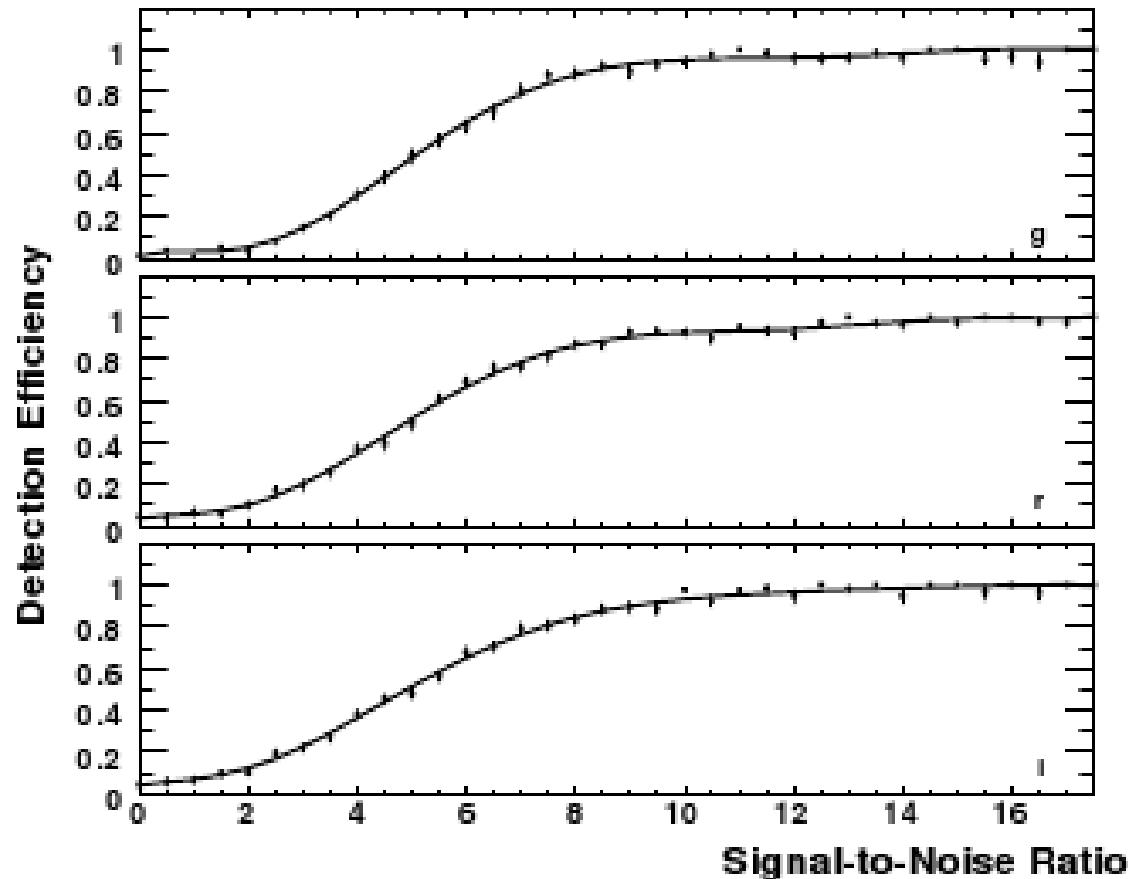
# DES vs. SNLS (rough estimate)

	SNLS	DES	Units
# Fields	4	2.5	~6 months/year
FoV	1	3	sq deg
Imaging total	1380	750	hr
Photometric?	75-80	50	%
Spectroscopy	1500	?	hr

Table courtesy of John Marriner



# Survey Efficiency for SDSS (software only)

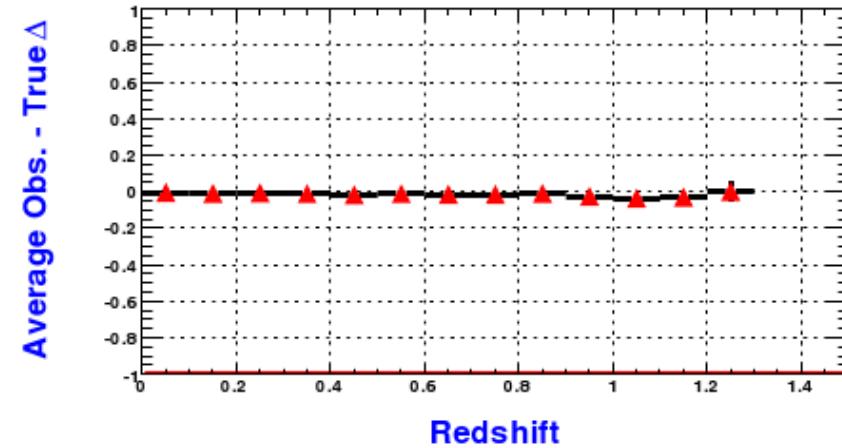
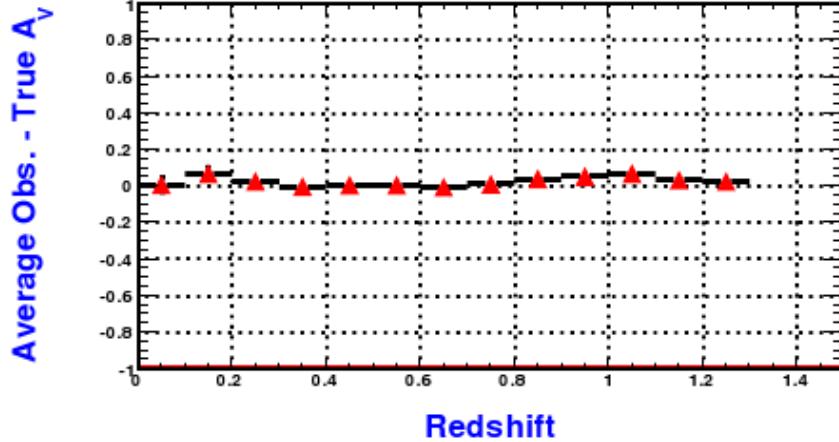


Dilday, et al., arXiv:0801.3297v2 (2008; accepted by ApJ)



# No Bias in $A_v$ or $\Delta$

Deep (grizY): cuts of 1 filter > 10 and any 3 > 5 S/N have been applied





# DETF Figure of Merit

Method	$\sigma(\Omega_{DE})$	$\sigma(w_0)$	$\sigma(w_a)$	$z_p$	$\sigma(w_p)$	$[\sigma(w_a)\sigma(w_p)]^{-1}$
BAO	0.010	0.097	0.408	0.29	0.034	72.8
Clusters	0.006	0.083	0.287	0.38	0.023	152.4
Weak Lensing	0.007	0.077	0.252	0.40	0.025	155.8
Supernovae	0.008	0.094	0.401	0.29	0.023	107.5
Combined DES	0.004	0.061	0.217	0.37	0.018	263.7
DETF Stage II Combined	0.012	0.112	0.498	0.27	0.035	57.9

Table 1: 68% CL marginalized forecast errorbars for the 4 DES probes on the dark energy density and equation of state parameters, in each case including Planck priors *and* the DETF Stage II constraints. The last column is the DETF FoM.  $z_p$  is the pivot redshift. Stage II constraints used here agree with those in the DETF report to better than 10%.

# Nearby SNe Ia spectrophotometry

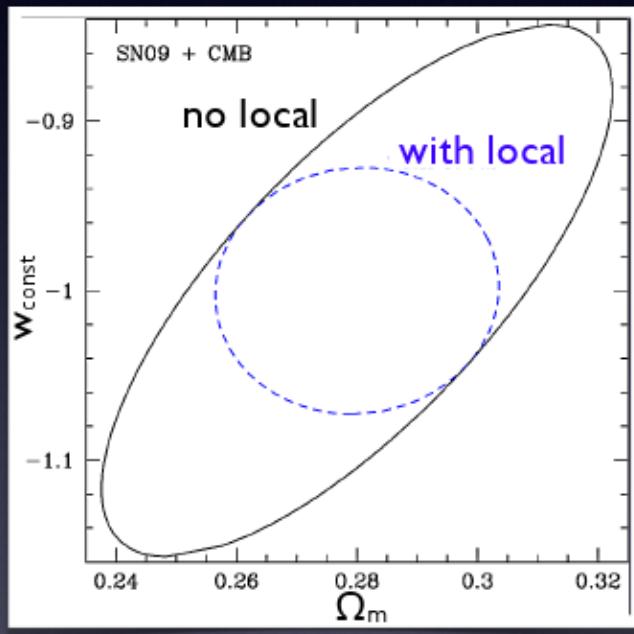
SNfactory status and current results

CRAL / IPNL / LPNHE - France  
LBNL / Yale - US

Rui Pereira - LPNHE Paris  
43rd Rencontres de Moriond  
16 March 2008

# SNfactory

- Built to tackle one of the biggest sources of statistical and systematic uncertainties on the cosmological analysis using high-redshift SNe: the nearby SNe sample



Linder 06

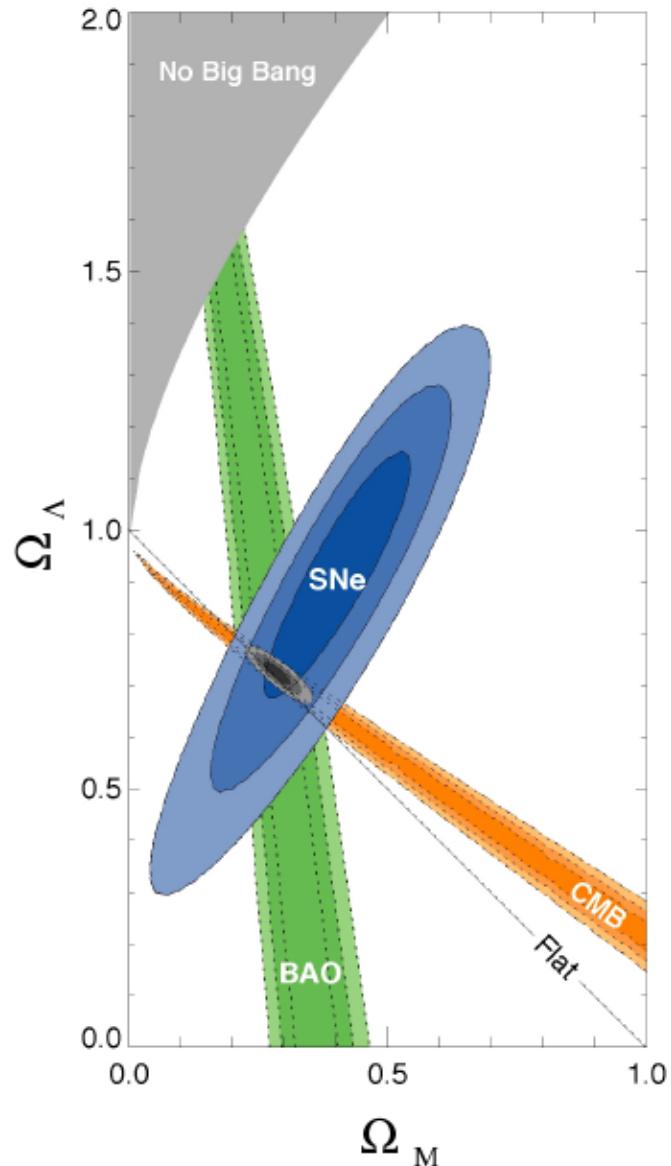
Systematic	w Error
Colour of Vega on Landolt system	0.0391
SNLS zeropoints	0.0311
SNLS bandpasses	0.0286
SN model	0.0278
Evolution in colour-luminosity ( $\beta$ )	0.0242
Landolt bandpasses	0.0146
Local flows	0.0137
SED of Vega	0.0131

Improved by new low-z sample

Conley AAS08

- Aims for a large spectroscopic sample (~200) of well-calibrated, well-sampled SNe Ia in the  $z = 0.03-0.08$  range

# Results: Cosmological fit parameters



Combination of SNe with:  
BAO (Eisenstein et. al., 2005)  
CMB (WMAP-5 year data, 2008)

For a flat Universe:

$$\Omega_m = 0.274 \quad 0.016(\text{stat}) \quad 0.012(\text{sys})$$

... and with curvature:

$$W_m = 0.285 \quad 0.020(\text{stat}) \quad 0.010(\text{sys})$$

$$W_k = -0.001 \quad 0.010(\text{stat}) \quad 0.005(\text{sys})$$

Cosmology with  
a photometric  
selection of type  
Ia supernovae in  
SNLS data

Gurvan BAZIN

# Cosmology with a photometric selection of type Ia supernovae in SNLS data

Deferred  
selection of type  
Ia candidates  
without  
spectroscopy

Data  
Supernova  
selection

Properties of  
selected sample

Photometric vs  
spectroscopically  
confirmed events

Impact on  
cosmology

Cosmology with  
purely  
photometric  
events

Gurvan BAZIN  
Nathalie Palanque-Delabrouille  
James Rich  
Vanina Ruhlmann-Kleider

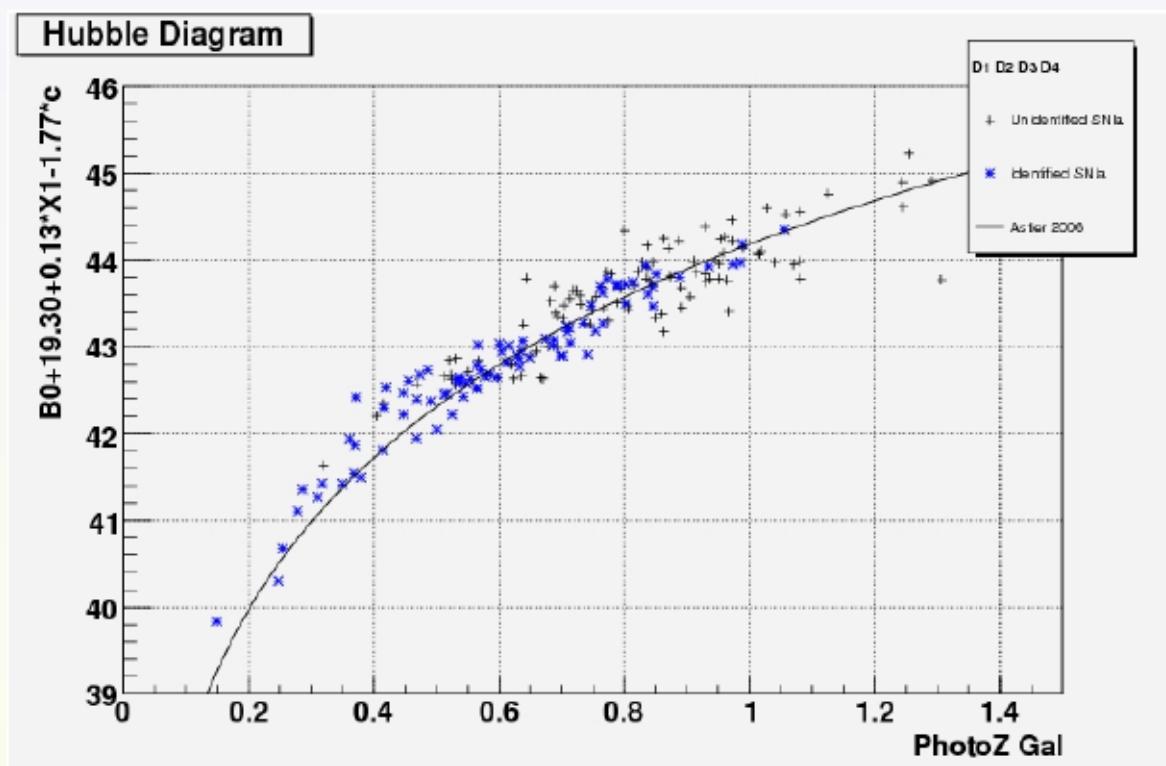
IRFU/SPP, CEA-Saclay, France

Moriond conference, March 15–22, 2008

# Impact on cosmology

Cosmology with  
a photometric  
selection of type  
Ia supernovae in  
SNLS data

Gurvan BAZIN



Deferred selection of type Ia candidates without spectroscopy

Data  
Supernova selection

Properties of selected sample

Photometric vs spectroscopically confirmed events

Impact on cosmology

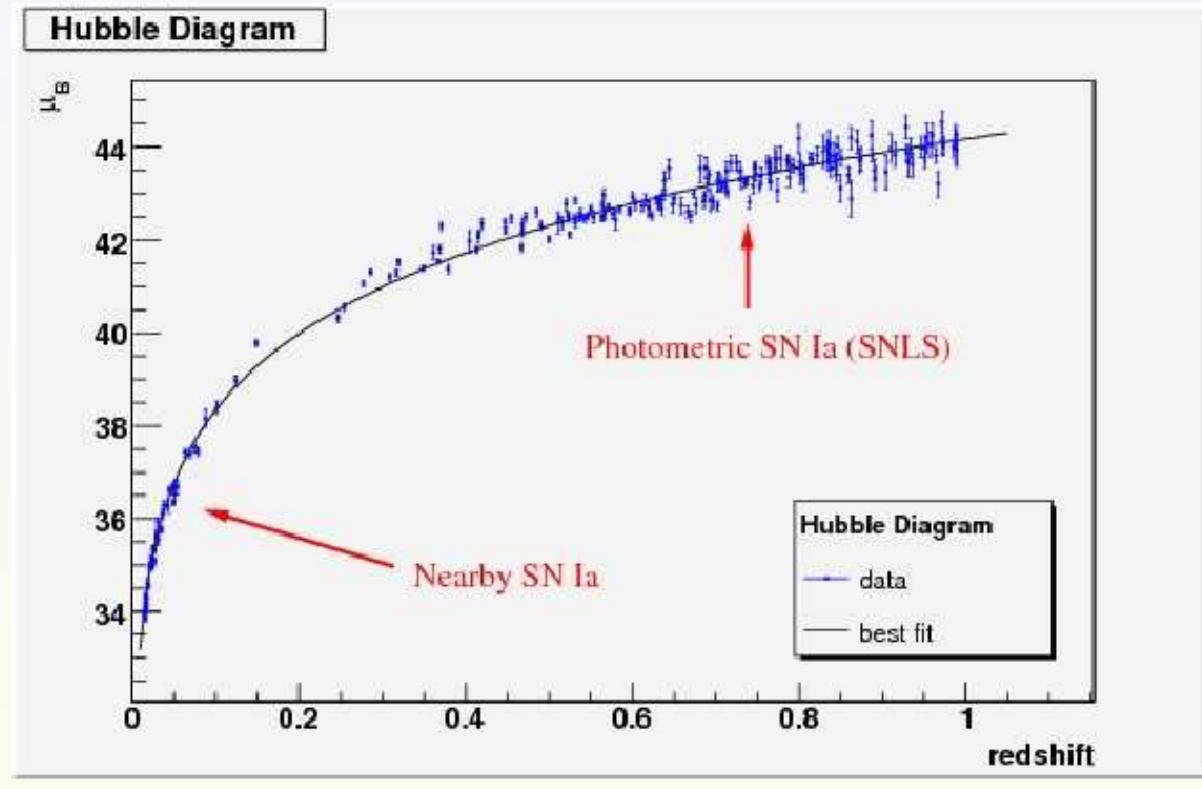
Cosmology with purely photometric events

- Residuals to the Astier et al. 2006 cosmology for the total sample and the identified subsample
- $z < 0.7$  : no significant difference in  $\mu_B$
- $z > 0.7$  :  $\Delta\mu_B = -0.052 \pm 0.034$  mag  
(incompleteness of the identified subsample)  $\Rightarrow \Delta\Omega_M = 0.014$

# Cosmology with purely photometric events

Cosmology with  
a photometric  
selection of type  
Ia supernovae in  
SNLS data

Gurvan BAZIN



Deferred  
selection of type  
Ia candidates  
without  
spectroscopy

Data  
Supernova  
selection

Properties of  
selected sample

Photometric vs  
spectroscopically  
confirmed events

Impact on  
cosmology

Cosmology with  
purely  
photometric  
events

- ▶ 174 distant supernovae ( $z < 1.0$ )
  - ▶ 44 nearby supernovae
- ⇒  $\Omega_M = 0.252 \pm 0.038(\text{stat})$   
(Cosmo Astier 2006 :  $\Omega_M = 0.264 \pm 0.042(\text{stat})$ )

# Probing the nature of dark energy..

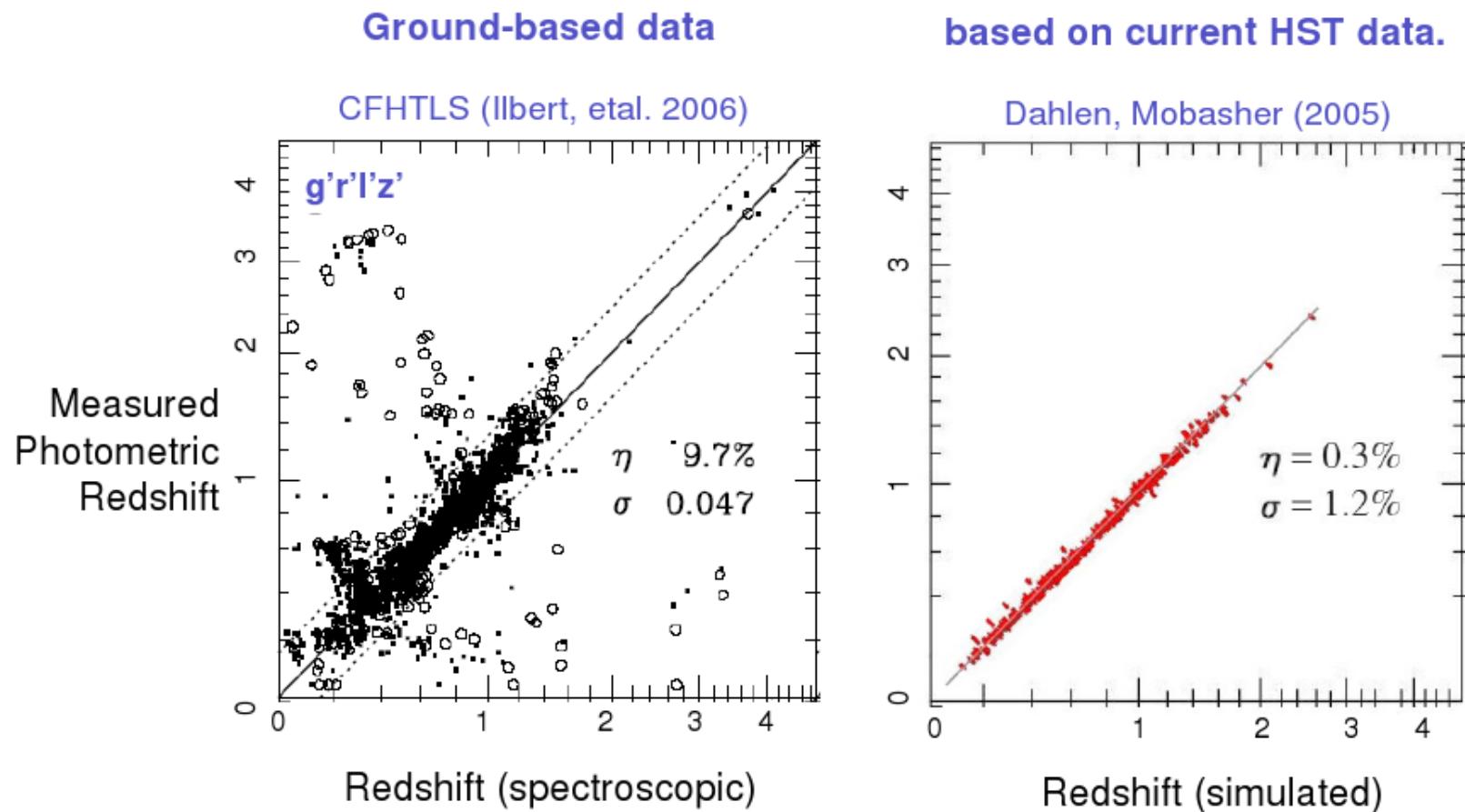


Require very precise measurements and interpretation:

- Compare effect of dark energy on the expansion rate (geometry) with the effect of dark energy on growth of cosmological structures (clusters)"
- Need more than one probe to do consistency tests between gravity effect and expansion history
- Most promising approaches : SNe, WL, BAO, clusters...
- All probes will be systematic errors limited

SNAP-L = clean, well controlled measurements for both SNIa (geometrical) and WL (dynamical) using space advantages

# Ground-based Photo-z Redshift Errors





# Conclusion

- **SNAP an already well advanced project**
  - **A wide space imager working both in visible and IR**
  - **A low resolution spectrograph onboard in visible and IR**
- **SNAP addresses first the dark energy problem**  
**but .. addresses many other sciences cases  
with its deep and wide surveys in 9 filters!**

**JDEM AO expected this year !!  
SNAP ready to answer**